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Compass Surveying

AND THE

Simplified Calculation

NOTICE.

Since publishing this edition of books, the author decided to quit using blue prints, and had two plates made, one-fourth the size of the original tracing. This of course reduces the scale of the Traverse Chart to one-half of the original scale, and the scale of the Map of the Carter Farm is changed from one inch equals forty poles to the scale one-half inch equals forty poles, or one inch equals eighty poles.

* * *

FIRST EDITION.

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1915

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Introduction.

Almost every person knows exactly how much money and other personal property he has, and is able to count it all by himself; but why shouldn't he also be *able to count his real estate?* Over 99 per cent. of all land owners have to leave this in the hands of *surveyors,* and have to depend entirely on their surveying and calculating. The land owners have no way at all of finding out whether the surveyor's field work was accurate or whether his calculation of the area is correct.

All farmers should know enough about surveying and calculating areas, so that they are not dependent upon others when it comes to dollars and cents. If you own a farm or if you are thinking of buying one, it will be a great source of satisfaction to you if you know how to calculate its area, so that you will not have to take another's word for it.

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No survey is *perfect,* and every time a farm is sold at so many dollars per acre, the buyer always gets either *more* or *less* land than he pays for. This difference may be very small and yet it may be very large if the survey of the farm was not accurate. The calculator is the only person who knows whether or not the survey *was* accurate. He may work out the area from the notes of an inaccurate survey and get an area several acres greater or less than the *true* area, and neither the buyer nor the seller would know anything about this large error. One or the other would either be buying or selling land that he did not possess. This custom *must not continue,* because many law suits are the result of it, and the author has written this simple little book for the sake of protecting all farmers and other land owners against such mistakes as these, and to enable them to know for themselves how much land they really have. Taxes are sometimes paid by people on land that they never owned.

The author's main object, while writing this book, was to make it as *short* as possible, because "much study is a weariness of the flesh", and he has tried to make the information as brief and interesting as he possibly could; however, all important details of the calculation are clearly explained.

Because such a very small number of people know how to calculate farm areas, it is generally considered quite a difficult task; but almost anyone can *multiply,* and that is the hardest part of the calculation. Addition and subtraction is all the rest there is to it. All numbers are placed in their proper columns, and the *building up* of the calculation is the only secret of it all. There is nothing else to it.

More than three-fourths of all college graduates do not know how to calculate land, and that should be one of the most important subjects taught; but the writer is sorry to say that such is not the case. It is so simple that anyone with *common sense* and the *ability to multiply* should soon be able to calculate land as rapidly as an experienced calculator.

In this little book the writer has tried to clearly explain this method step by step, and in such a simply manner as to make it exceedingly plain. The "whys and wherefores" of the *theory* in this calculation are explained so as to make the study of it a very pleasant task.

Just enough information about *Compass Surveying* is given in this book to lay a firm foundation upon which is based the theory of the Calculation of Farm Areas.

This book is intended especially for all land owners, lawyers, real estate agents, inexperienced surveyors, students, and all who should know, or would like to know, how to calculate the area of a tract of land having more than four sides.

The manner in which the two calculation sheets and the map are arranged in the back of the book enable the reader to glance from one to the other with ease, and this greatly facilitates the study of it. A 32-sided farm, located in Smyth County, Virginia, and calculated to contain 840.14 acres, is taken as an illustration. This farm is divided up into two divisions, and a separate check calculation is made of each division, making a total of four calculations. This check method, explained within the book, shows whether or not the calculated area is correct.

Of course, it may be necessary for some readers to study through this book three or four times, and probably more, before they are thoroughly familiar with the entire calculation; the amount of study required will, of course, depend upon the reader's mental aptitude. However, if he is quick at figures, he should understand the entire process after he has carefully read through the book only once. The writer firmly believes that the Calculation of Land by Latitude and Departure cannot be explained in a clearer and simpler manner than it is within this little book, for he has tried to write just as if he were talking to the reader face to face.

CHAS. M. THOMAS.

Wytheville, Va., Dec. 30, 1914.

CHAPTER I.

A LESSON EXPLAINING THE COMPASS.

As we all know, there are four principal directions, which are NORTH (N), SOUTH (S), EAST (E), and WEST (W). A *True* North and South line is an imaginary straight line extending along the Earth's surface from the Earth's North Pole to its South Pole. Such a line is PERPENDICULAR to the EQUATOR, the Equator being an East and West line. A True North and South line is called a TRUE MERIDIAN. An East and West line is a line that is perpendicular to a North and South line.

A MAGNETIC North and South line is an imaginary straight line extending along the Earth's surface and pointing towards the North MAGNETIC Pole. This Magnetic Pole is a point in Northern Canada where the DIPPING NEEDLE points straight *down*—that is, the *North* end of the needle points down and the South end points *up*. There is another Magnetic Pole on the opposite side of the Earth, which enables people over there to survey just like we do, by using the MAGNETIC NEEDLE or COMPASS, as the surveying instrument is called. This is an instrument for determining directions upon the Earth's surface by means of a magnetized needle turning freely upon a pivot and pointing in a *Magnetic* Northerly and Southerly direction; that is, the *North* end of the needle points towards the North *Magnetic Pole.*

The SOUTH end of the needle can be easily told by its having a fine wire wrapped around it, and fitted loose enough to allow the wire to be moved either towards the pivot or towards the end of the needle. This wire is used to keep the needle balanced or level. The position of the wire on the needle depends upon the locality in which the compass is used. The farther North, the more the needle will dip, hence the wire must be moved farther out towards the end of the needle so as to keep it level. It is on the same principal as a *see-saw.* If you had been using a compass in Florida, you would have to have the wire closer to the pivot than it would be if you were using the same compass in one of the Northern states. Think out the reason, if you didn't grasp it at first.

It is unnecessary to go into details concerning the appearance and specifications of a compass fit for surveying purposes, because you will learn more about one after examining it for ten minutes than you could by reading a long description of one. However, here are all of the instructions necessary to tell you how to care for, read, and run a compass:

1. Never carry the compass unless the needle is CLAMPED, because it is injurious to both the needle and pivot, and the needle might possibly fall off the pivot.

2. Never carry a compass on a TROLLEY CAR, unless you place it on the *back platform,* as the magnetism from the motors will *demagnetize* the needle and cause the North end to touch the glass top.

3. When determining the direction *(bearing)* of a line, *always* keep the SOUTH sight *next* to your eye, and read the NORTH end of the needle.

CHAPTER II.

HOW TO READ THE COMPASS.

The only slight difficulty for the beginner is Reading the compass; that is find the bearing (direction) of a line when the compass is sighted on it, by looking at the North end of the needle.

We all know that any *two* points determine the Direction or Bearing of a line. The Line of Sight on the compass is determined by the slit in the sight on the South end of the compass and the slit in the sight on the North end of the compass. However, this does not mean that the line of sight is always North and South, because the compass, with its sights, is revolved in any direction. It is the Needle that always points *North* and *South*. Before anyone can intelligently read a compass, it is best for him to understand something about the Four Quadrants, Degrees, etc.

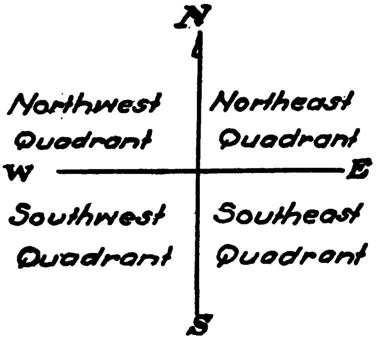


FIG 1

Figure 1 shows a diagram with the four directions on it, which are as follows: North (N), East (E), South (S), and West (W).

THE N. E. QUADRANT.

A quadrant is simply a QUARTER of a CIRCLE or its CIRCUMFERENCE. A line whose bearing is exactly North, is said to be *due* North. An East line is said to be *due* East. A line that has a bearing between a North line and an East line is said to have a Northeastern direction or N. E. The bearing is N. so many degrees E., say N. 30.° E., (°) standing for the word *degrees*. It is much easier for you to understand quadrants and degrees if you will take out your watch and go through the following lesson:

Starting at figure 12, on your watch, it is easily seen that there are 60 short and equal divisions around the entire circumference through the figures 1, 2, 3, etc., back to 12. As you well know, these divisions are called *minutes*, but instead of all circles being divided into only *60* equal divisions they are divided into *360* equal divisions. If you draw 360 lines from the center of *any* circle to each of these 360 points on the circumference, you will have 360 DEGREES, a *degree* being that small difference in direction between any pair of the 360 lines. A degree does *not* depend on the length of its sides, of course. So you see, there are 6 times as many degrees around a circle as there are minutes on a watch, and each one of these minutes contains 6 degrees, 360 divided by 60 equals 6. In 5 minutes there are 5 × 6 equal to 30 degrees; in 10 minutes there are 10 × 6 equal to 60 degrees; in 15 minutes there are 15 × 6 equal to 90 degrees. This amount is called a Quadrant or RIGHT ANGLE.

Draw a circle a little larger than your watch. Draw a

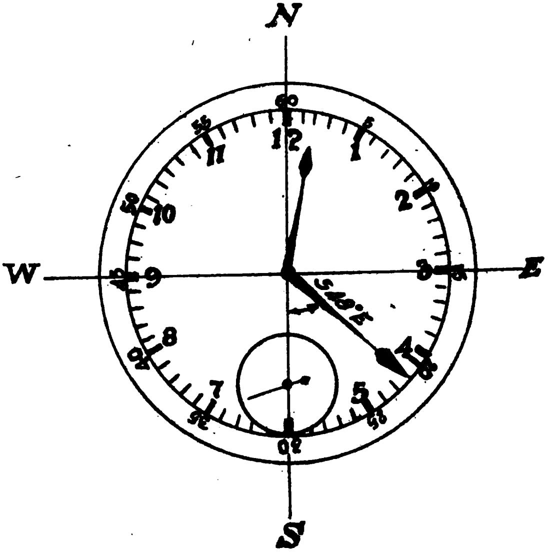


FIG 2

vertical diameter and a horizontal diameter, as is shown in figure 2. Mark the diagram with the four directions in their proper places, as is shown. Place your watch over this diagram so that the figure 12 on the watch will be towards the N. of the North and South line. This will throw figure 3 on the E. line, figure 6 on the S. line and figure 9 on the W. line. Then the N. E. quadrant lies between 12 and 3. The S. E. quadrant lies between 6 and 3. The S. W. quadrant lies between 6 and 9, and the N. W. quadrant lies between 12 and 9.

The Bearing of a line or course is the number of degrees in the angle formed by the line itself and a North and South line.

Now pull out (or push in) the stem of your watch so that you can turn the hands. Turn the minute hand to the figure 12. It now points due North. (Here it would be a good idea if you would have the 12 on the watch and the N. on the diagram pointing towards the *true North* as well as you can judge.) When the hand is pointed to the figure 3, it then points due East. When it is on figure 1, its bearing is N. 30 degrees E. When it is on figure 2, its bearing is N. 60 degrees E. When it is on the 14 minute mark, its bearing is then (14 × 6 equal to 84) N. 84 degrees E. When on the 1 minute mark, its bearing is N. 6 degrees E, as it is then only 1/15th of the way around the N. E. Quadrant, and 6 is 1/15th of 90. There are 90 degrees in each quadrant. 90 × 4 equals 360, the number of degrees around any circle. RULE: To find the bearing of the minute hand on any minute mark, multiply the number of minutes between 12 and the minute mark by 6.

THE S. E. QUADRANT.

Set the minute hand on figure 6 or the 30 minute mark. Then its bearing is due South. When set on the 29 minute mark, its bearing is S. 6 degrees E. When on the 28 minute mark the bearing of the minute hand is then S. 12 degrees E. When it is set on the figure 5, its bearing is S. 30 degrees E. When on 4, its bearing is S. 60 degrees E. When on the 18 minute mark the bearing is S. 72 degrees E., and so on for any position in this quadrant. RULE: To find the bearing of the minute hand on any minute mark in the S. E. quadrant, subtract the number of the minute mark from 30 and multiply the difference by 6 (the number of degrees in 1 minute on the watch). The result will be the proper number of degrees to place between the letters S. E.

THE S. W. QUADRANT.

When the minute hand is on figure 9, its bearing is due West. When on figure 7, its bearing is S. 30 degrees W. When on the 37 minute mark, its bearing is S. 42 degrees W. When on the 37½ minute mark, the bearing is then S. 45 degrees W. or exactly South West, as it is then midway between South and West. When on the figure 8, the bearing is S. 60 degrees W. RULE: To find the bearing of the minute hand on any minute mark in this quadrant, subtract 30 from the number of the minute mark, and multiply the difference by 6 (the number of degrees in 1 minute on a watch or clock).

THE N. W. QUADRANT.

As said before, when the minute hand is on the figure 9, its bearing is due West. When on figure 10, its bearing is N. 60 degrees W. When on figure 11, its bearing is N. 30 degrees W. When on the 52½ minute mark, its bearing is N. 45 degrees W. or exactly North West. When on the 57 minute mark, the bearing is then N. 18 degrees W. RULE: To find the bearing of the minute hand on any minute mark in this quadrant, subtract the number of the minute mark from 60 and multiply the difference by 6.

REVIEW OF THE FOUR QUADRANTS.

Set the minute hand on the figure 12, and slowly turn it through figures 1, 2, 3, and so on through the four quadrants. Now, always remember that from 12 to 3, the bearing *in*creases from 0 to 90 degrees. From 3 to 6, the bearing *de*creases from 90 to 0 degrees. From 6 to 9 the bearing *in*creases from 0 to 90 degrees, and from 9 to 12 the bearing *de*creases from 90 to 0 degrees. Now set the minute hand on figure 12 again; also have the *hour* hand pointing to 12. Your watch now reads 12 o'clock, and both hands point due North. Turn the hands very slowly in a clockwise direction. When the *hour* hand points N. 6 degrees E. the minute hand points N. 72 degrees E. When the *hour* hand points N. 12 degrees E. the minute hand points S. 36 degrees E. When the *hour* hand points N. 18 degrees E. the minute hand points S. 36 degrees W. When the *hour* hand points N. 24 degrees E. the minute hand points N. 72 degrees W. When the *hour* hand points N. 30 degrees E. the minute hand points due North again. *Between each reading the Minute hand was moved through 12 minutes, making the Hour hand move through only 1 minute.*

NOTE: Each *degree* is divided into 60 equal subdivisions which are very small; these are called *minutes,* but of course not the same minutes as are on a watch or clock which contains 6 degrees and each degree contains 60′ (minutes). Therefore, in 1 minute on a watch or clock there are 6 × 60 equal to 360′ (Surveying minutes). Hence, in the circumference of any circle there are 60 × 360′ equal to 21,600′ (minutes). If the *circumference* of the Earth, at the Equator, were divided into 21,600 equal parts, the distance in each part would be a small fraction over 1 1/7th miles, and this distance is called a *Nautical* Mile or KNOT. So when you hear of a ship whose speed is 28 *knots* an hour, its speed in miles is 28 × 1 1/7, equal to slightly over 32 *miles* an hour. 21,600 × 1 1/7 equal to almost 24,700 miles, which is approximately the circumference of the Earth in English miles. So you see, a minute on the watch is 1/60th part of a circumference, and an *angular* minute is 1/21600th part of a circumference, and is indicated by the sign (′). However, with a compass, a surveyor rarely, if ever, reads his bearings closer than to the nearest ¼ degree, = 15′ (minutes).

A VERY SIMPLE EXPERIMENT TO MAKE YOU FAMILIAR WITH THE COMPASS.

When you first look at a compass you will wonder why the E is on the *West* side of the compass and why the *W* is on the *East* side of the compass. This can be very easily understood by performing the following experiment: Take four pieces of paper, about the size of your hand; on one make the letter N. for North; on the second piece make an E. for East; on the third make an S. for South, and on the fourth piece make a W. for West. Hold the N. between your teeth, the E. in your *Left* hand, the W. in your *Right* hand, and pin the S. to your coat-tail. Now, every person, with ordinary intelligence, generally knows the four directions N., E., S., and W. pretty close, especially if he is at *home*. Now stand up straight and face towards the North. Stretch your arms out straight from your body and in opposite directions. Then your *Left* hand holding the E. points *West*, and your *Right* hand holding the W. points *East*. *Whichever letter is exactly* NORTH *of you tells you the direction* *you are facing.* In the first position, the N., held between your teeth, was on the *North* side of you and told you that you were facing *North.* Now turn slowly to your right through the N. E. quadrant, and stop when your left hand holding the E. points North. This *E.* on the North side of you tells you that you are now facing *East.* Turn on through the S. E. quadrant until your back is to the North. The *S.* pinned to your coat-tail is on the North side of you and tells you that you are now facing *South.* Continue to turn in the same direction through the S. W. quadrant until your *Right* hand holding the *W.* is on the North side of you and points towards the North. This shows you that you are now facing *West.* Turn through the N. W. quadrant until you face North again. You have then turned through the 4 quadrants of 90 degrees each, or through a total of 360 degrees. During this exercise, the *North* line represents the *North* end of the magnetic needle on the compass, and the direction you were facing represents the *line of sight* of the compass. Study figures *3-A, 3-B, 3C* and *3-D*. *3-A* is a compass sighted on a line in the N. E. quadrant; *3-B* represents a compass sighted on a line in the S. E. quadrant; *3-C* represents a compass sighted on a line in the S. W. quadrant, and *3-D* represents a compass sighted on a line in the N. W. quadrant. Examine each of the four diagrams very closely. Each figure shows how the compass is read in that quadrant. You will now see the value in performing the preceding experiment.

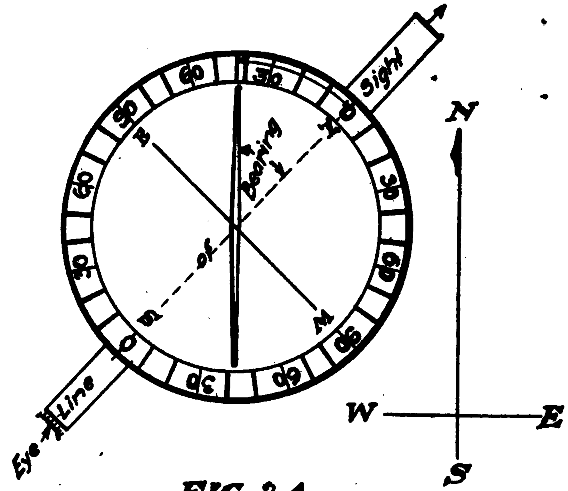

Eye
Line of Bearing
Sight
N
E
S
W
N
S
E
W
30
60
90

FIG. 3A

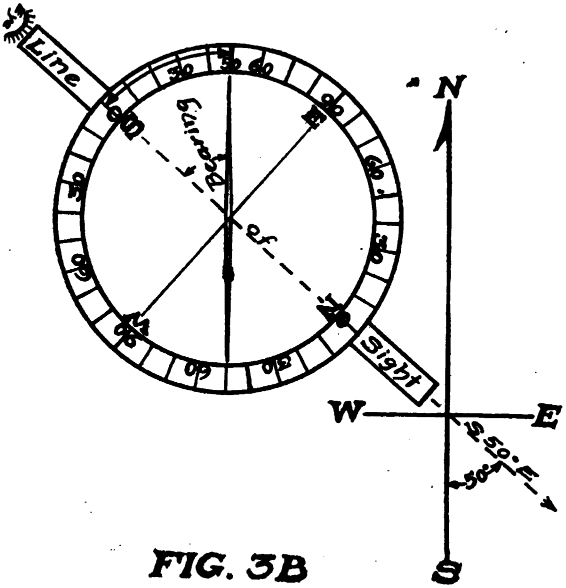

Line of Bearing
Sight
N
E
S
W
N
S
E
W
S.50°E.
50°
30
60
90

FIG. 3B

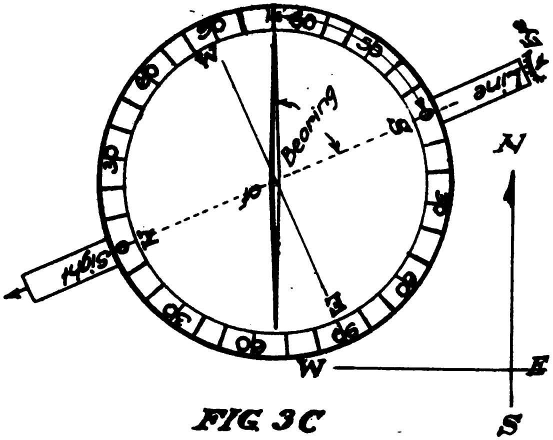

Line
Eye
Sight
Bearing
N
S
E
W
N
E
S
W
30
60
90

FIG 3C

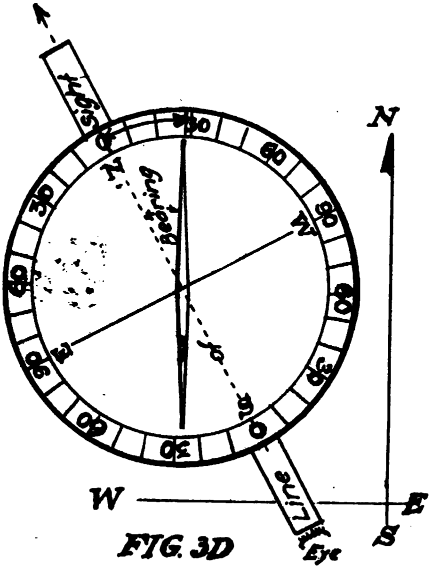

Sight
Line
Eye
Bearing
N
S
E
W
N
E
S
W
30
60
90

FIG. 3D

Let me impress upon the student right here how necessary it is for him to use his common sense while running a compass. If you are certain that the line you are running with your compass has a southwesterly direction, don't let this fact vanish from your mind when you read the compass, as you might forget and read the South end of the needle instead of the *North* end, or you might read the North end of the needle correctly, but you might have the North sight of the compass next to your eye instead of the *South* sight next to your eye. I will repeat the rule again: *Always keep the South Sight of the Compass next to your Eye and always read the Bearing at the North End of the Needle.* In reading a bearing always be certain of the direction in which the degrees *increase* before you note the bearing in your note-book; if you do not do this, you will very probably make the mistake of reading a 69 for a 71, or a 42 for a 38, and so on, at each of the 9 degree numbers of 10, 20, 30, etc., in each quadrant. You should be very careful when you are running a line almost due North or South and not put down a bearing S 1 degree E, when it should be S 1 degree *W*, and the same care should be used when you are reading the bearing of a line that is almost East or West. The quadrant that contains the line of sight is always the same quadrant on the compass that contains the *North* end of the needle. However, the line of sight always has two directions which, of course, are opposite and have a difference of 180 degrees. A line whose bearing is N 5 degrees W when you are facing toward the North, has the bearing S 5 degrees E when you sight on it in the opposite direction. In like manner, a line whose bearing is N 40 degrees

E also has the bearing S 40 degrees W, and so on for any line. The number of degrees are always the same, but N and S are interchanged, and E and W are interchanged.

A bearing always has N or S *first,* and is never read E so many degrees N (East so many degrees North), nor West so many degrees South. This shows a complete ignorance of surveying on the part of the person stating bearings in such a manner. A bearing should *always* be read or spoken of as *North* so many degrees East (or West); and *South* so many degrees East (or West); whichever it happens to be.

Now, if the foregoing rule and principals are closely observed and studied over a few times, any person with an average amount of common sense and a small amount of education should soon be able to know all that is necessary to run a compass with accuracy.

CHAPTER III.

HOW TO CHAIN.

It is very important that the compass should be run with accuracy; but unless the CHAINING (measuring of lines) is also done with accuracy, the survey will not *close* as well as it should, and the fault is not altogether the surveyor's. (The *closing* of a survey will be explained later.)

The areas of farms are always figured in ACRES; one acre containing 43,560 square feet, being equal to a *square* lot, each side of which is 208 feet, 8½ inches long. However, tapes divided into *feet* are rarely used in the survey of a farm with a compass. As said above, there are 43,560 square feet in *one* acre. In 1/10th of an acre there are 43,560 sq. ft. divided by 10, equal to 4,356 square feet. This area is equal to the area of a *square* lot, each side of which is 66 feet, because 66 ft. × 66 ft. equals 4,356 *square feet*. This length of 66 feet was chosen as a unit of measure by a surveyor named Gunter, after whom the chain is named. This Gunter's chain is the measuring unit that is used in most compass surveying. It contains 4 *Poles* or *Rods* (a unit of measure 16½ feet long); 4 × 16½ equals 66 feet. There are 10 square chains in one acre, and, as is easily seen, there are 4 × 4 equal to 16 square rods or *Perches* in one square chain. So in *one acre* there are 10 × 16 equal to 160 square rods or perches.

When the Length of a Line is Given in Poles or Rods, Divide the Number of Poles or Rods by Four (4), and the Length will then be Expressed in Chains.

Every chain is divided into 100 equal parts called *Links*. The length of each link in inches is 66 × 12 inches divided by 100, equal to 7.92 inches. So you see, the length of one link is almost 8 inches. Sometimes a *steel tape* is used instead of the old-fashioned chain, and the tape is divided into 100 equal parts of 7.92 inches each, the length of one link. A steel tape is better to use over rough ground, where the joints in a chain are likely to catch in the thick brush.

Eleven Pins are used by the two chainmen. It is hard for some people to understand why *11* pins are used to measure off *10* chain lengths. (These *Pins* are strong pieces of wire about one foot long, curved into a ring at one end and sharpened at the other end.) It is easy to understand why 11 pins are used if you will follow these instructions: Take 11 matches (brass pins will answer better), lay one down on the top of a table; now lay the next one exactly 1 inch from it and *parallel* to it (pointing in the same direction). Continue this until you have laid all 11 matches down, leaving a 1-inch space between them, measuring from the center of one match to the center of the next. After all 11 matches are down, measure from the center of the first match to the center of the last match on the other end of the row. Of course, you will find the distance to be only 10 inches. Now, when the two chainmen start measuring the length of a line, the front chainman takes 10 of the pins, and leaves the rear chainman one pin, which he sticks in the ground at the *corner* or end of the line. When the front chainman has gone out one chain's length, the rear chainman hollows out "stick" and holds the back end of the chain exactly even with the pin. The front chainman stops, stretches the chain tight and holds it as near *level* as possible. Two plumb-bobs should be used, one by each chainman. In chaining up a hill the rear chainman will have to hold his plumb-bob over the pin, and the other end of the plumb-line exactly even with the end of the chain—that is, if it is 66 feet from one end of the chain to the extreme end of the other end. However, in some chains there is about an extra foot at each end. The chaining must be done from the front end of the *first* link and from the *rear* end of the *last* link; the chainmen should know exactly where the *zero* and the back end of the last link is before they start on the job. The front chainman, after being certain that the chain is level, sticks a pin in the ground exactly under the zero mark of the chain, if the front chainman has the front end of the chain. He then hollows "Stuck", while the rear chainman holds his end of the chain exactly over the pin, which he pulls up and carries along with him after the front chainman hollows "Stuck". This operation is continued, the rear chainman pulling up each pin not until *after* the front chainman sticks a pin in the ground and hollows "Stuck". *After* the front chainman sticks his last pin in the ground, he hollows, "Out", and the compassman keeps account of all the "outs", each *out* making a distance of 10 chains. While his last pin is in the ground, the front chainman waits for the rear chainman to bring him up the 10 pins which he has pulled up along the line, but the 11th pin is left in the ground. The pins should always be counted after each "out", as one might get lost and cause an unnecessary delay in searching for it. Now, to understand this operation or method of chaining, it will be a good idea for you to get a yard stick or tape line. Place the yard stick on a table or on the floor so that the zero end is to your left, as will be the case if the figures are not up-side down. Now let your *right* hand represent the front chainman, and your *left* hand represent the rear chainman. Take 10 matches in your *right* hand and one in your left hand. Place the match which you held in your left hand at the zero (0) end of the yard stick or tape line. Now place a match out of your right hand on 1 inch, then pick up the match at the (0) end of the yard stick with your left hand and lay down another one out of your right hand on the 2nd inch, and continue this operation, always laying one down out of your right hand *before* picking the rear match up with your left hand. Always have one match on the yard stick. (This shows that you should *always* have a pin in the ground while you are measuring a line.) An "out" should occur every 10 inches, and the operation is then repeated, after the 10 matches in your left hand have been transferred over to your right hand. The number of pins held by the rear chainman, counting the one in the ground, indicates how many chain lengths the *front* chainman is from the beginning of the line, or if one or more "outs" has occurred, the number of pins shows the front chainman's distance from the point where the *last* "out" occurred. Therefore, if there has been two "outs" along the line, and the rear chainman holds 6 pins, and has one more still in the ground, while the front chainman holds the (0) end of the chain on the corner, and the rear chainman finds that link No. 25 is even with the pin in the ground, then the distance from the last corner is 10 × 2 + 6.25 chains, equal to 26.25 chains or 105 *poles.* Here the front chainman reached the corner before he stretched out the 7th chain length, which would have thrown him 75 links or .75 of a chain beyond the corner.

Now, I will tell you why the chain has to be held horizontal or level when chaining. It is just on this simple principal that land is surveyed: No matter how steep the roof of your house is, its area is no greater than the area of the floor space of the first story, or the area included within the foundation walls (with the exception of the extra amount of roofing around the eaves). Because you can well see that the roof would not catch any more rain, no matter how steep it may be, than it would if it were level. You may have a steep hill on your farm, but its area is no greater than if the ground were perfectly level at that place A survey is simply a *projection* on a level plane.

CHAPTER IV.

INSTRUCTIONS TO FOLLOW WHILE SURVEYING.

Suppose you have to survey a piece of land bounded by *fences.* Set the compass on the *Jacob's Staff* or *Tripod* (which should be stuck firmly in the ground) at one of the corners. Sight the compass along the fence, or exactly on the next corner, if it can be seen. Keep the chainmen in line while they are measuring. Put down the proper bearing in your note-book, and after the chainmen reach the next corner, find out the distance from them, and put it down in your note-book, opposite the bearing of the line they have just chained. Also put down, on the right hand page of your note-book, a description of all corners, etc. Then set up on the next corner sight on the corner beyond if it is in view, if not, then sight along the fence the best you can.

Never set up a Compass within Five (5) Feet of a Wire Fence, as the wire will deflect the needle from its Northerly direction; but sight the compass at a *Flag Staff* offsetted as far from the fence as the compass is from the fence. This will give you the proper bearing of the fence, provided it's straight, of course. Also keep the axes and other instruments of steel or iron several yards away from the compass when you are taking a bearing. A *Flag Staff* is a pole with a white or red piece of cloth tied to the upper end of it, and carried by a flagman. (When snow is on the ground, a black piece of cloth should be used instead of a white piece.)

It it all right to keep the farm you are surveying either to your right or left; but it is customary to keep it on the right of the line—that is, to survey in a clockwise direction (the direction of the hands of a clock).

When there is no fence on the line to be surveyed, and one corner can't be seen from another, a *Deed* giving the *Metes* and *Bounds* of the tract is required. (*Metes* and *Bounds* are simply the bearings and distances of the courses.) The compass is set on the bearing called for at this corner, and the flagman (the man who uses the flag staff) is lined on the proper bearing, as far as he can be seen by the compassman. The flagman holds this point until the compass man comes up and sticks the Jacob's staff in the ground at this point, and sets the compass on the same bearing, and lines the flagman again. This operation is repeated until the corner is reached. It is not likely that the corner will be hit exactly, but measure from the corner over to the *nearest* point on the line just run; multiply this distance by 57.3. (57.3 is equal to 180 degrees divided by 3.1416—this last number, 3.1416, being the number of times the *diameter* of any circle will go into the *circumference* of the *same* circle.) Now, after you have multiplied the di stance you missed the corner by the decimal 57.3, then divide the product by the length of the entire line. The result is the number of degrees between the bearing used on the trial line and the proper bearing that would have hit the corner exactly. As for example: Suppose you ran a line, say 28.65 chains long, on the bearing N 68 degrees W and ran to the *left* of the corner, missing it by the distance of 1.25 chains, and you wish to calculate the proper bearing. It is done as follows: 1.25 × 57.3 ÷ 28.65 = 71.625 ÷ 28.65 = 2.5 or 2½ degrees. Therefore the new line will be 2½ degrees over to the *right* of the *trial* line and its bearing will be N 68 degrees minus 2½ degrees W, equal to N 65½ degrees W. This is shown in Figure 4.

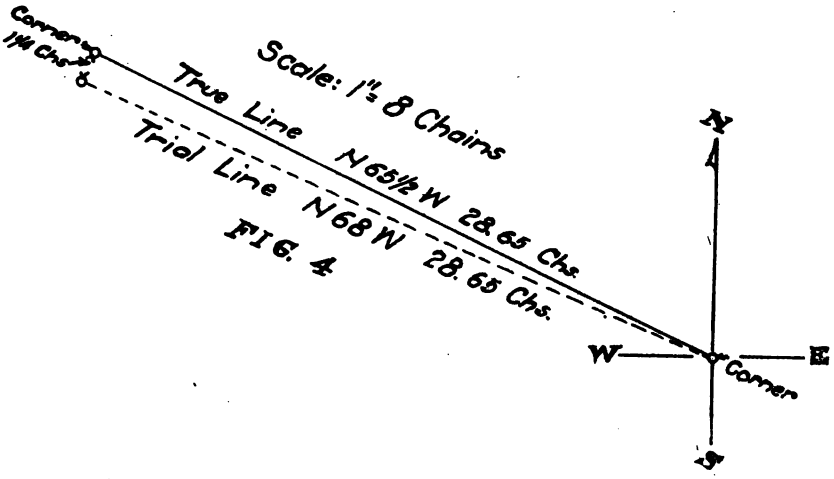


FIG. 4

There are many difficulties that you might encounter while surveying, but I will not try to give suggestions in this brief volume as to how to overcome these problems. I will ask the reader to use his common sense in every instance and he will have no trouble in overcoming them for himself.

A survey is not finished until the surveying party has gone completely around the farm, or tract, and has returned to the starting corner.

The notes should be kept in the following manner:

LEFT HAND PAGE.

Corners.	*Bearings.*	*Distances.*
1 to 2	N 43° E	14.48 Chs.
2 to 3	S 58° E	9.23 Chs.

3 to 4, and so on around the entire survey.

RIGHT HAND PAGE.

No. 1—Pile of Stones on W bank of creek.
No. 2—Large White oak on N side of spur.
No. 3—Double Chestnut oak on top spur.

CHAPTER V.

VARIATION OF THE MAGNETIC NEEDLE.

In the conclusion of BOOK ONE, it will not be out of the way to tell the reader some few facts about the *Variation* or *Declination of the Magnetic Needle.*

Write to the U. S. Coast and Geodetic Survey, Washington, D. C., for its latest *"Isogonic Chart"*. This chart shows the difference between the *Magnetic* North and *True* North for any point in the United States at a certain date. Throughout the *Middle Atlantic* and the *New England* States the needle points *West* of a True North line by different amounts in each State. In 1902, in Southwest Virginia this difference was only about 1 degree, and in Tidewater, Virginia, the difference was 4 degrees. This West declination continues to increase every year. In Virginia the increase is about 1 degree for every 20 years. In re-surveying an old line, pull your new line over to the *Right* the proper number of degrees, the difference in declinations. If you are surveying *West* of the line of *no variation,* pull your needle line over to your *Left* the proper number of degrees.

The DECLINATION of the Magnetic Needle is the ANGLE between a TRUE NORTH LINE and a MAGNETIC NORTH LINE. This angle or declination is always changing at a very slow rate in some parts of the United States and more rapidly in other parts. In 1905 this declination in Southwest Virginia was changing at a rate of 2′ for every year; or, in other words, the declination was *increasing* at a rate that would make the Magnetic Needle point 1 degree farther *West* of a *True North* line every 30 years. In Eastern Virginia the declination was increasing *Westward* at the rate of 1 degree for every 20 years.

There is a crooked line extending through the United States, from Michigan down through South Carolina. At all points on this line the magnetic needle points exactly towards the *True North Pole* as well as towards the *Magnetic Pole.* At all of these points the *Magnetic North Line* and the *True North Line* have exactly the same direction, and the magnetic needle points true north and south. At all places in the United States *West* of this *line of no declination* the magnetic needle points *East* of a *true North* line, and the angle between these lines is gradually *decreasing* at different rates. In Montana, Western Wyoming, Utah, and Arizona, the *Eastern* declination *de*creases at the rate of 1 degree every 20 years. In Eastern North and South Dakota, Nebraska, Kansas, Eastern Oklahoma and Eastern Texas, Western Arkansas, and Western Louisana the *de*crease in *Eastern* declination is about 1 degree every 30 years. In Minnesota, Iowa, Missouri, Western Tennessee, and Eastern Mississippi the *de*crease in *Eastern* declination is about 1 degree every 60 years. In Wisconsin, Illinois, Western Kentucky, Middle Tennessee, and Eastern Alabama *there is no change in declination.* In Indiana, Eastern Wisconsin, Middle Kentucky, East Tennessee, Georgia, and Florida the declination *in*creases *Westward* at the rate of about 1 degree every 60 years. In Michigan, Ohio, Western West Virginia, Eastern Kentucky, Southwest Virginia, Western North Caroline, and South Carolina the declination of the needle *in*creases *Westward* at the rate of about 1 degree every 30 years. In New York, Pennsylvania, Maryland, Eastern Virginia, and Eastern North Carolina the declination *in*creases *Westward* 1 degree every 20 years. In the New England States the declination *in*creases *Westward* at the same rate of about 1 degree every 20 years.

This *change* in the *Declination* of the *Magnetic Needle* is called the *Variation of the Needle* and is quite a perplexing problem among surveyors.

This *in*crease in the *Westward* declination for all points *East* of the *Line of No Declination* as well as the *de*crease in the *Eastern* declination for all points *West* of the *Line of No Declination* has been continuing ever since about the year 1800. For example: at Baltimore, Maryland, in the year 1680 (the first known observation), the magnetic needle pointed almost 6 degrees *West* of a *true North* line; this angle gradually *de*creased at about 1 degree every 20 years. In the year 1800 the needle pointed about ½ of a degree *West* of a *true North* line, but this declination has been *in*creasing ever since at about the same rate of 1 degree every 20 years. In 1880 the needle pointed about 4 degrees *West* of a *true North* line. This *in*crease in the *Western* declination and the *de*crease in the *Eastern* declination will continue until about 1940 or 1950 and after this date the declination will reverse; that is, the *Western* declination will *de*crease until about the year 2100.

In Paris, France, in the year 1600, the magnetic needle pointed 9 degrees *East* of a *true North* line. In 1800 it pointed 22 degrees *West* of a *true North* line; a difference in the declination of 31 degrees in 200 years.

The foregoing facts are to show the reader how necessary it is to record the *date* and *declination* of the needle on all plats and records of surveys and to state whether the bearings given are the *True* or *Magnetic* bearings. A *true bearing* is a bearing taken from a *true North* and *South* line instead of a *magnetic North* and *South* line. The advantage of *true bearings* is that they never change, just for the simple reason that the direction of the North Pole, from any point on the earth's surface, never changes. A *True* survey is much more accurate and reliable than a *Needle* survey. The only difficulty in making a *True* survey is to find the exact direction of a *true North line.* This is done by means of a *Transit,* either by sighting it on the *North Star* and making the necessary corrections, or by sighting the transit on the *Sun* at about 9 a. m. or 4 p. m. The elevation or altitude of the sun is noted. From a formula involving spherical trigonometry, the sun's *bearing* East and West of a true North and South line is calculated, and this determines very accurately the direction of the *true North* and *South* line.

Most all of the land surveying done by the U. S. Government and many mining companies is *True* surveying; that is, the bearings are taken from a *true North* and *South* line, which is exactly the same as the *longitudinal lines* which you will notice on most all maps (these are the lines drawn up and down the map). This kind of surveying, True surveying, is about 30 or 40 times more accurate than ordinary compass surveying.

CHAPTER VI.

SOME POINTS OF LAW GOVERNING SURVEYS.

Many *Legal* questions arise among land owners over *Boundary Lines* between them, and a large number of fatal fights have been the result of quarreling over boundary lines. Such a custom of settling the dispute by a fight should not continue. The contention may be due to several causes, the principal causes of which are having the original or first survey made by a surveyor who should never be allowed to look through a compass. The cause might be due to an error in the chaining. However, the main reason for quarrels over boundary lines is due to the fiery temper, bull-headedness and ignorance of one, or perhaps both of the land owners on each side of the boundary line. The contending parties should, if possible, agree upon a competent surveyor and have him come upon the land, with a *Deed* of *each* tract of land owned by *each* party. The surveyor should *compare* the *bearings* and *distances* for this boundary line in each deed. He should see where these *calls* for the same boundary line *disagree,* and he should try, as near as possible, to satisfy both parties; however, he should carry out the *law* by all means, in regard to boundary lines, even if both parties are not satisfied. Always remember that it is *not* the *bearing* that determines the direction of a *boundary line,* nor does the *distance* always determine the *length* of it, but it is the *corners* that determine both the direction and the distance of the line. If the *corners* can be identified beyond a reasonable doubt, then the *True Line* (a straight line joining the corners) is the established line required. No matter what the bearing or distance is, the *true corners* determine the *true line.*

As has been said before, the *Magnetic* bearings of all lines are continually changing every year, and this *variation* is never known exactly. So you see that it would not be common sense to try to determine the direction of a course or boundary line by the *Bearing* alone. In chaining distances, the chainmen are not particular about trying to hold the chain *level* when chaining up and down hill; however, the chain or tape should always be held level at all times, unless *slope measurement* is supposed to be taken. Therefore, the *chaining* can't be the determining distance between corners. It is the distance, measured horizontally between the *corners* that determines the proper length of the line.

If a fence has been built along what is supposed to be the *division* or *boundary* line, and has been on the same line for 10 years or more, and has not caused any contention among the land owners on each side of the fence, then this fence *has to remain where it has been in the past,* no matter if it isn't exactly where the deed calls for it to be. This is the law when the *adverse user* of the small strip of land can show some kind of a deed which *seems* to give him *legal title* to the strip, but which by reason of some mistake fails to do so. In this case the man is said to hold *adversely "with color of title".* However, without such written deed or other agreement his holding is said to be *"without color of title".* When the holder cannot show any color of title for the property he adversely holds, then the law provides that 20 years of adverse possession are necessary before the holder has a clear title to the property. Any survey of such a line, after the elapse of such period of time required by law, is *valueless.* This is the case when the line fence has been set by agreement of both parties that it should be the boundary line, right or wrong.

However, if the fence is built *off* the division line for convenience only, both parties agreeing that it is *not* the boundary line, then possession of this kind has been held *not* to be adverse.

The *public* can get adverse possession against any person, but no person can get adverse possession against the public. The public has the right to use private property as a road. On the other hand, a person might fence up a road and use it for 20 years or more, but this does not give him a title to the fenced land. The road at any time could be used again.

As has been well said, "The total ignorance of, or disregard for, the application of adverse possession in determining boundaries is a fruitful cause of expensive and useless law-suits."

A surveyor has no legal right to fix or to establish anything, but should try, on all occasions, to see that his work complies with fitting decisions rendered by the Supreme Court of his State.

In all cases of doubt, concerning inaccurate surveys, deeds, titles, etc., the courts in construing the law are inclined to favor the purchaser.

When a boundary line is defined as a certain distance between two corners, one of which is uncertain, the *distance* governs the location of the uncertain corner. But if both corners are recognized as being the certain ones, then the distance does not govern, as has been said before.

When a course is described as running from one corner to another the line is presumed to be a *straight* line; however, if it is *not so stated* to be a *straight* line, it may be construed to be taken as a crooked or curved line if it is understood to follow some natural feature of the landscape. There is a case to come up in June, 1915, before the Supreme Court of Virginia on this very point, at least it was the intention of one of the contending parties to appeal the case when the writer last heard from him. There were two corners on the top of a ridge, and the description calls for a line running from one of these corners to the other. The ridge is curved between these corners. One of the parties contends for a *straight* line between these corners, and the other party contends that the line should follow the meanders along the top of the ridge. The writer does not know exactly how the description reads, but he awaits the decision with interest.

If there is nothing stated to the contrary, the words "southerly" "westerly", etc., are construed to mean *due* south, *due* west, etc.

If all of the boundaries of a tract of land are given and seem to be correct, then the boundaries govern the area, if the area happens to be incorrect. But if the boundaries are in doubt, then the area may govern.

Unless a survey is incorrect or inaccurate, it should close when platted; that is, when the person platting the tract of land from the notes of a survey of it, he starts at a point which he takes as the beginning, lays off the *bearing* of the first course with his PROTRACTOR (a half-circle divided into 180 degrees), and scales off the proper distance with his rule divided into inches, he then lays off the bearing and distance of the second course from the other end of the line, and continues this simple little operation until he has platted all of the courses. The end of his last course platted should fall exactly on the beginning point, if there was no mistake in the survey or the platting. However, remember that in platting, a magnetic north and south line has to be drawn through each corner to enable the person platting to lay off his bearings correctly. Of course, all of these north and south lines drawn on the platting paper should be exactly *parallel.* It is the best idea to plat on paper that already has parallel lines ruled on it so that there will be no trouble in drawing the north and south lines parallel. As has just been said, all surveys should close, but they never do unless they are *perfect,* and this is very seldom the case, as you will see later. The surveyor is usually allowed to correct the bearings and distances (which result from his calculating the *Latitudes* and *Departures,* as you will see later), and he should use very good judgment in doing this part of the calculation, as too much of this kind of correcting means a loss of money or land to one of the parties in case of a sale. Even the calculator himself rarely knows whether the area he calculated from an inaccurate survey is *more* or *less* land than what is really there, and right here again is where the law wants the doubtful acreage construed in favor of the purchaser.

When one course of an old survey can be identified with certainty, it is a good idea for the surveyor, who is making a resurvey of the same tract, to sight his compass on this line, getting as long a sight as possible, and note the *present* bearing of the line. The difference between this bearing and the bearing of the same line called for in the deed of the old survey is the amount of *variation* that has taken place between the dates of the surveys. This declination should be used on all the other lines of the tract to enable the surveyor to follow the *true* lines.

A few more words in regard to Adverse Possession will conclude this chapter. As should have been stated before, adverse possession has been defined as "an actual and visible appropriation of land commenced and continued under claim of right, inconsistent with and hostile to the claim of the true owner". Adverse possession is very similar to statute of limitation concerning the nonpayment of old debts. If we did not have this law of adverse possession the courts would be open "to stale claims which experience has shown spring up at great distances of time when important witnesses are dead or material evidence is lost or destroyed."

The laws differ somewhat in different states and these laws should be investigated by land owners before they lose money by expensive wrangling in the court-room. A great deal of money is lost in law-suits just for the simple reason that one land owner wants to be sure that his contentious neighbor shall not get an inch of land from him; and, strange to say, this is generally the opinion that each party has about the other.

Book II.

Simplified Calculation
OF
Farm Areas.

CHAPTER I.

A FEW SUGGESTIONS AND INSTRUCTIONS TO THE READER.

Now, all that is necessary to calculate the area of a farm having any number of sides is to know how only to add, subtract, multiply, and divide by short division. There is nothing hard about the calculation at all, and please don't get it into your head that there is anything difficult about it either. You know that $7.25 stands for seven dollars and twenty-five cents, and in like manner any number such as, say 3.72 chs. on the calculation sheets means three chains and seventy-two *links,* or 72/100th of a chain. Each one of the above numbers is a Decimal Fraction. In fact, every time you write any sum of money of any number of dollars and cents you write down a decimal fraction. The point coming between the dollars and the number of cents is called the Decimal Point. As you see, it is nothing but a *period.* When you multiply two decimal numbers together *count* the number of figures to the *right* of the decimal point in both numbers (the Multiplicand and the Multiplier). Point off as many figures to the *right* in the product as there are in both of the numbers multiplied together, as shown in the following examples:

3.432 × 2.41 = 8.27112. Also .624 × 2.1 = 1.3104
123 45 54321 123 4 4321

The top numbers are the numbers multiplied together. The bottom numbers simply show how to properly *count* the figures to the *right* of the numbers multiplied together, and in the product the bottom figures show how to count and point off the proper number of figures. In the product, always start counting from the *right hand* end of the number. You have now, right in the beginning, mastered the hardest part of the computation, as all the rest of it is simply addition, subtraction, and short division, as I have said before.

Look at the map folded in the back of the book. It is a map of a farm in Smythe County, Virginia, surveyed into two divisions, the WESTERN DIVISION and the EASTERN DIVISION. It can be seen at a glance that this farm has about 30 or 40 sides and its area could be calculated only by an experienced surveyor; but if you will give me your most careful attention and use your good common horse sense, I will make the calculation so plain to you that you can't help but understand it. However, remember that in all of the columns from 2 to 19, *always* place *all decimal points exactly* under each other.

On most all maps, the bottom of the map is South and the top of it is North, but there should always be an *arrow* shown on the map and this arrow should show which direction is North by pointing in that direction. On most maps, a North and South line points straight up the map. Look at the map of the farm very closely. Notice which direction is North and which is South. Of course, East will be to the right of this Meridian, and West to the left of it. What direction did the compassman survey around the farm? You will have to look at only one boundary line to learn that he kept the farm to his *left*—that is, he surveyed in a *counter* clockwise direction, opposite to the direction in which the hands of a clock or watch move. If he had surveyed in the opposite direction or clockwise direction, he would have had all of his bearings *reversed*; the number of degrees would have been the same for each line, but the changes would have been an N for S, or S for N; likewise a W for E, or an E for every W.

As you noticed on this map, the N and S line points up the map. North being at the top.

We will first calculate the area of the Western Division. This calculation is on Sheet 1, in the back of this book. Study the map and columns 1, 2 and 3 *only,* of Sheet 1, at the same time. Start at the most Western corner, No. 1, as you will see numbered on the map. See that the numbers of the corners, bearings and distances on the map agree exactly with columns 1, 2 and 3, on Sheet 1. Notice that the distances on the map are given in *poles.* These distances are divided by 4 to convert them into *chains,* which are given in Column No. 3. Add together the sixteen distances given on the map in poles, divide the sum by 4, and see if your answer checks the number 311.81 chs., the sum of Colmun No. 3.

Now, don't try to learn all of Sheet 1 all at once. The study of Sheet 1 is very much like climbing a ladder, but instead of having 19 rounds or steps, it has 19 *columns,* and you are supposed to take the trip very steady, step by step, and not act like a *monkey* would, by jumping from round to round, sometimes up and sometimes down, because when he gets through jumping about, he's just as likely to be at the bottom as he is at the top.

It would be a very good idea for you to keep all of the columns to the right covered up with a separate piece of paper and uncover them and study them in their proper order. If you can't understand each column at first, don't get discouraged, but keep steadily at it and you will soon get results.

CHAPTER II.

EXPLANATION OF THE FIRST THREE COLUMNS.

(These three columns are the surveyor's notes taken while surveying around the farm.)

Column No. One, A and B.

Colmun No. 1-A contains the numbers of the corners *from* which the surveyor sights his compass, and *at* which he reads the *Bearing* and puts it down in his note-book on the same horizontal line to the right in Column No. 2. Column No. 1-B contains the numbers of the corners *to* which the surveyor sighted his compass, and *at* which he puts down in his note-book the *distance* just measured from the last corner. These distances make up Column No. 3

The survey is begun as follows: The surveyor sets up his compass at Corner No. 1 (with South sight next to him) and sights to Corner No. 2. *After* the needle has *settled,* he reads the bearing of the line from Corner No. 1 to Corner No. 2, being careful not to get the bearing reversed. As I have said before, *always* be certain that the *S* sight is *next* to your eye, and that the bearing you read is at the *North* end of the needle. After you are certain of this, then put down the bearing on the same horizontal line to the right. Be sure that the chainmen *keep on the line while measuring.* After you have put the proper bearing down in your note-book, pick up your compass and Jacob's Staff and go to the next corner, No. 2, if you sighted all the way to it from Corner No. 1, but if it could not be seen from Corner No. 1, go to the point where the flagman has his flag pole in the ground. (When you line the flagman up each time, be certain that he holds the flag staff *plumb,* or vertical.) Line him up again and continue this until you reach corner No. 2. After the chainmen have measured to Corner No. 2, put down the distance, in your note book, from Corner No. 1 to Corner No. 2, and put it down on the same horizontal line to the right of the corresponding bearing (the bearing from Corner 1 to Corner 2).

As I have said above, Columns No. 1, No. 2, and No. 3, are the only columns that are obtained in the field. They are called the *Metes* and *Bounds* of the farm. These should be put down in a note-book in a neat and proper form. By all means do not *lose* your note-book, as it will cause much trouble and will very probably mean a re-survey of all the courses that the book contained, except those courses that have been calculated or worked up. However, *all* note-books should be saved.

Be certain to describe all corners and their natural locations. Do this on the right-hand page of your note-book.

Column No. Two.

This column contains all of the bearings, in their proper order, from Corner No. 1 all the way around the farm back to

Corner No. 1. As you can see, most of the bearings are read to a fraction of a degree, ¼ degree being about the smallest fraction of a degree that can be read on the *compass;* however, you will notice that the first bearing is S. 32 degrees 22′ (minutes) E., which is the same as S 32 11/30 degrees E, because 22/60 equals 11/30. I suppose that this line must have been run with a TRANSIT, when the adjoining farm to the West was surveyed, as no needle reading can be read that close.

Trace all of these bearings around the map to see that they all check out the same. You will note that the DIVISION LINE, from Corner 7 to Corner 8, has its bearing reversed from what it is on the map; on Sheet 2 this bearing is the same. The reason why this line is reversed is very plain: When it was surveyed the surveyor started at its North end and ran it S 12½ degrees E 453 poles.

COLUMN NO. THREE.

This column contains all of the distances, between corners, in their proper order, from Corner No. 1 around the entire farm and back to Corner No. 1. These distances are in *Chains* of 66 feet each. All of the distances added together make a total of 311.81 chains, or 311 chains and 81 *links,* or 311 81/100 chains. As has been said, the relation between CHAINS and LINKS is exactly the same as the relation between *dollars* and *cents.* A POLE or ROD has the same relation to a Chain as a twenty-five-cent piece has to a dollar—that is, the *ratio* of ¼th to 1, equal to the *ratio* of 1 to 4.

If you have not already done it, add together all of the distances around the *Western* Division (which distances are given on the map in *poles*), and see if you do not get 311.81 × 4 equal to 1247.24 *poles.* Whenever the distances around a farm are given in *poles or rods,* and you wish to find the area of the farm, it is always the best to divide the length of each course by 4, this gives its length in *chains.* After you have finished dividing all of the courses by 4, find the total number of poles around the farm by adding all the courses; divide this total by 4, and see if it doesn't check the total number of chains around the entire farm. If it doesn't, then find your mistake and correct it.

CHAPTER III.

EXPLANATION OF COLUMNS NO. FOUR, NO. FIVE, NO. SIX, AND NO. SEVEN—THE LATITUDE AND DEPARTURE COLUMNS.

Column No. Four—Latitude; North (Plus).

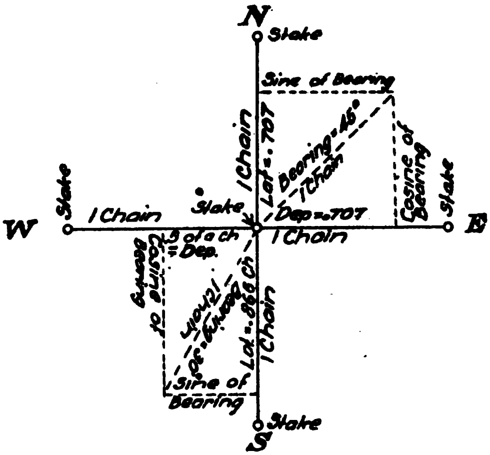
Now don't get scared and imagine you have now struck something that you know nothing about; because you *do* and I will show you that you know much more about this part of the calculation than you think you do, as the next four columns are the prettiest part of the entire calculation, and by far the most interesting, as you will soon find out.

These four columns are in *two pairs*: Columns No. 4 and No. 5 are the Latitude pair, and Columns No. 6 and No. 7 are the Departure pair. The *Departure* of a line or course is simply the distance that one end, or corner, of the course *departs* away from a *North* and *South* line through the other corner—this is, its distance East or West of the North and South line through the other corner. Suppose you have a fence on your farm that is almost on a North and South line; that is, the direction of the fence is North and South. If you start from one end of the fence and walk in *any* direction, except North and South, and as you continue walking in a straight line, you will find yourself getting farther and farther away from the fence line. You see, you are *departing* from the N and S fence line. This is all there is to the new word called *Departure.* So we are now acquainted with departure and will be ready for the Columns No. 6 and No. 7 when we come to them.

We are now on the *Latitude* pair, and the first one of the pair, the *North* column. *TheLatitude of a course is simply the distance that one corner of the course is North, or South, of an East and West line through the other corner.*

We can easily illustrate what is Latitude and Departure by the following experiment, performed at your earliest convenience. Drive a stake in the ground in one of your level lots (a piece of ground about 150 feet square is all that is necessary). Perform this experiment after you have carefully studied the few lines which follow. Take a ball of cord and tie one end of it to a tack, or small nail driven in the top of the stake in the ground. Measure off 1 chain's length (66 feet) in a North direction, as well as you can judge. Drive in a stake here and tie the cord to it, after it is stretched fairly tight. Cut off the remainder of the cord. Go back to the first stake, with the tack in it. Tie the string to it again, and measure 1 chain's length towards the South, in exactly the opposite direction from the North line. Drive in a stake here and tie the cord to it also. (The string need not be more than 1 foot above the ground.) All three stakes should now be in a row, forming a North and South line. Now measure 1 chain's length towards the East, from the center stake, and measure 1 chain's length towards the West, from the center stake. Drive in a stake at the East point and one at the West point. The East and West line should now be *perpendicular* to the North and South line. There should be five stakes in the ground, two for the N and S line, two for the E and W line (which should also be connected by the cord), and a fifth stake where the two lines *cross*; this fifth stake was the first one driven. Each line is 2 chains long—132 feet. The North and South line is the *Latitude* line, and the East and West line is the *Departure* line.

Now, if you start at the center stake and walk exactly North or South, keeping one foot on each side of the N and S line, the entire distance you walk is your *Latitude.* You didn't go East or West, therefore you have no *departure* in your course, because it was either due North or South, and when you stopped you were no farther East or West than you were at first, when you were on the center stake. Now go back to the center stake and start out walking on the *East* and *West* line. The entire distance you walked is *Departure,* and there is no *latitude,* because when you stopped walking you were no farther North or South than you were at first. Suppose you started at the center stake again and walked on the bearing N 45 degrees E the distance of *1* *chain,* or 100 links. Then your latitude and departure will be the same; each will be .707 of a chain, or 70.7 links. You are now .707 of a chain farther North and .707 of a chain farther East than you were before you left the center stake. Suppose you start at the center stake once more and walk in the direction S 30 degrees W 1 chain. You can easily see that when you stop at the end of the chain's length, your latitude will be greater than your departure, because you are .866 of a chain farther South than you were when on the center stake, and only .50 of a chain farther West than you were. *No matter what bearing you walk on, if you always walk out only 1 chain's length from the center stake and keep in a straight line, your Distance from the East and West Line* (expressed as a fraction of the chain's length) *is the* Cosine *of the Bearing; likewise the Distance you*



Scale: 1" = 1 Chain

FIG. 5

are from the North and South Line is the SINE *of the Bearing.* The *sine* of 30 degrees is .50, and the *cosine* is .866. The *sine* of 45 degrees equals the *cosine,* equal to .707. I will now try to tell you all there is to *Sines* and *Cosines.* Study very carefully the diagram shown in Figure 5.

COSINES AND SINES.

Every angle or bearing has its *Sine* and *Cosine.* The sine of 0 degrees is 0 (zero). The cosine of 0 degrees is 1, and the cosine of 90 degrees is 0. The sine of 90 degrees is 1. The value of a sine or cosine is always between 0 and 1. The sine of 45 degrees is .707, and the cosine is .707 also, because 70.7 links divided by 100 links equals .707. This is the only angle for which the sine and cosine are equal. The sine of 30 degrees is .5, and the cosine is .866. You will find, in the back of this book, a table of cosines and sines for all the angles from ¼ degree up to 90 degrees, with an increase of ¼ of a degree throughout the table. This table shows you the sine and cosine for any bearing, that is read as close as ¼ of a degree. This is as close as the bearings are read on the compass.

The Length of any Line or Course Multiplied by the COSINE *of its Bearing gives the* LATITUDE *of the Course;* that is, the distance one of its ends is *North* or *South* of the *other* end.

The Length of any Course Multiplied by the SINE *of the Bearing gives the* DEPARTURE *of the Course;* that is, the distance one of the ends is *East* or *West* of the *other* end.

The *Sine increases* as the bearing *increases.* The *Cosine decreases* as the bearing *increases.*

The sines and cosines of angles are very simple, and c easily understood by performing the following experi which should not, by any means, be omitted: Get a pi string, not more than 2½ feet long. Tie your pocket kn other small weight to one end, then measure out 1 foot alon string and tie another knot, just 1 foot from the knot a knife; then measure out 1 foot more along the string an another knot near the free end of the string. We now three knots in the string, with exactly 1 foot between them. will call the knot at the free end of the string Knot No. 3, middle knot, No. 2, and the knot at the knife, No. 1. T knot No. 3 in your right hand and place it on the right-ha corner of a table. Take knot No. 2 in your left hand (betwe the thumb and forefinger) and hold it on the *edge* of the tab which will be 1 foot to the *left* of knot No. 3. The knife wi then hang down about a foot or more below the edge of the table The knot No. 1 should be exactly 1 foot below the edge of th table. Gradually raise knot No. 2 with your left hand, keeping the string stretched tight. The distance, *expressed as the fraction of a foot,* from knot No. 2, down along the plumb line to the *edge of the table,* is the *Sine* of the angle made between the edge of the table and the string from knot No. 3 to knot No. 2. The distance, *expressed as the fraction of a foot,* from knot No. 3, along the edge of the table out to the plumb-line is the *Cosine* of the same angle, but is the *Sine* of the angle made by the string at knot No. 2.

The sine of an angle is always *opposite* the angle. The cosine of an angle is measured on one of the *sides* of the angle.

Simplified Time Chart

(From Patent News, May, 1924.)

"A "Simplified Time-Chart," patented March 11, 1924, by Lieut. Chas. M. Thomas, U. S. Coast and Geodetic Survey, Washington, D. C., is unique, interesting and useful, shows in a simple graphic form the relationship between Longitude and Time, giving the time all over the world at any time of day and at any place of known longitude. It shows the four different divisions of standard time throughout the United States, and also explains the perplexing question of how a ship gains or loses a day when it sails across the 180th meridian of longitude, something that is very hard for most folks to understand.

The inventor first developed this "Simplified Time-Chart" while he was in the U. S. Navy, pursuing the study of navigation. The chart has been very highly recommended; a knowledge of same should be possessed by students throughout the schools and colleges of the world, especially those studying geography, mathematics, navigation, astronomy, aviation, telegraphy and radio. A copy of this chart should be in every book published on geography and in every book on navgiation.

At the bottom of the "Simplified Time-Chart" is an explanation of same, which reads as follows:

"As most all of us know, the earth is divided into 360 degrees of longitude, 180 degrees east and 180 degrees west of the prime meridian, a true north and south line through the astronomical observatory at Greenwich, a suburb of London, Eng., denoted by 0 degrees. The earth revolves on its axis, from the west towards the east, once every 24 hours, and therefore the noon path of the sun moves in the opposite direction over the surface of the

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the east towards the west, and crosses over 15 degrees of longitude every hour, because 360 degrees divided by 24 hours equals 15 degrees per hour. The heavy vertical line in the center of the chart, marked 0 degrees, is the prime meridian and the other 24 vertical lines are the meridians of longitude every 15 degrees. The 25 horizontal lines, are the hour lines, including 24 spaces which represent the 24 hours of the day, from noon at Greenwich, November 10, 1918, till noon of the next day, November 11, 1918, one hour after the World War ended. The historical importance of this date is the reason it was taken as an example, although this chart is good for any date in any year.

The chart can be more easily understood if it is rolled into the form of a cylinder, making the two 180th meridians coincide, and then held vertically and imagined to be revolved once in 24 hours, and at the same time very slowly raised through its height, that is from the top noon line to the bottom noon line. For example find the civil and the astronomical time at London and also in Japan, longitude 135 degrees east, when it is 8 P. M., July 4th, 1920, at Washington, D. C. Pick out the 75 degree meridian of west longitude, and on it find the 8 in the P. M. zone. Trace this hour line out to the right. At London the civil time is 1 A. M., July 5th, astronomical time is 13 hours, July 4th, 1920, as you find the 1 and the 13 on the zero meridian at the intersection. In Japan the civil time is 10 A. M., July 5th, and the astronomical time is 22 hours, July 4th, 1920, as the 10 and the 22 are found at the proper intersection. The astronomical dates begin and end at noon, 12 hours after the civil dates begin, and are not denoted by A. M. or P. M. The hour line next to the bottom line gives the time all over the world at the hour when the World War ended.

The difference between the Greenwich mean time shown on the zero meridian and any other local mean time any place on the earth on the same hour line when multiplied by 15, gives the longitude of the place, astronomical time being used.

Boat No. 1, and Boat No. 2 represent 2 boats which happen to be crossing the 180th meridian when the World War ended. No. 1 going east had only 23 hours of Monday, the 11th; will do only 1 hours of Sunday, the 10th, but has Monday to do over again. Boat No. 2 skips 1 hour of Sunday and 23 hours of Monday. Its path shows it to be a faster boat than No. 1, doing more longitude in 23 hours."

The idea of the "Simplified Time-Chart" is a correct combination of a Mercator's Map of the World, with the hour meridians of longitude on the chart, which are shown every 15 degrees east and west of the prime meridian. With this combination the time all over the world can be read off at a glance by reading the time at the intersection of the proper meridian through the place whose time is sought and the horizontal hour line, which is never still, but is assumed to be slowly moving down the face of the chart once every 24 hours, but always parallel to the top and bottom of the chart. When this horizontal time line is at the top of the chart, it is exactly noon at Greenwich and at all points along the prime meridian; is 7 A. M. eastern time in the United States, and is midnight at all points along the 180th meridian in the Pacific Ocean, which largely corresponds to the International Date Line. At this moment each day begins. This horizontal line moves slowly down the face of the chart, and when it is half way down, it shows the time along the prime meridian to be midnight; 7 P. M. eastern time in United States and is noon at all points along the 180th meridian. The bottom line of the chart corresponds to the top line, so the process is repeated when the time line reaches the bottom, and another day is started from the top line.

By the use of this Time-Chart, clocks can easily be made that will give the time all

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over the world. These clocks will be in the form of either a vertical or horizontal cylinder, which revolves once in 24 hours, in the latter case.

This “Simplified Time-Chart” should be in every telegraph and cable office, on all sea going ships, at every radio station, and in every home where there is a radio receiving set, so that all parties concerned can tell the time at any part of the world. Every passenger sailing across the Pacific should have one of these interesting Time-Charts so that he can easily understand just why a ship gains or loses a day when crossing the 180th meridian, a ship sailing east having an extra day of 24 hours to do over again, while a ship sailing west skips a day of 24 hours when the 180th meridian or International Date Line is crossed, this line being sometimes called the “Sunday-Monday” Line. Should a ship be lying at anchor with its bow to the east, and lying exactly across this “Sunday-Monday” line theoretically, it would be Sunday for the folks in the forward part of the ship (to the east side of the line), and Monday for those in the after end of the ship (to the west side of the line), according to the date of the “Simplified Time-Chart.” This interesting but puzzling problem which very few folks can understand, is made very simple and clear by using the Chart.

The Astronomical dates are also shown on the Chart, and the relationship between Civil and Astronomical time is made quite clear. This makes the Time-Chart of much value and interest to students of navigation and those interested in same.

Due to the rapid rate at which the nations of the world are becoming more closely associated and connected by means of navigation, aviation, telegraphy and radio, the usefulness and value of the “Simplified Time-Chart” should continue to increase with great rapidity.”

These Charts can be ordered from the Inventor. Price: $0.50.

UNIV. OF MICH.

What Others Have to Say About

Compass Surveying
AND THE
Simplified Calculation of Farm Areas

Price $2.00

A Few Reasons Why You Should Own This Book.

This is not exactly a text book, but it is a book that is intended to help the farmer and to protect him against mistakes that might be made by surveyors.

Land is gradually increasing in value all over the U. S., and this naturally calls for more accurate surveying. If you own a tract of land, be it large or small, you should know, as near as possible, the exact area of your land. If you buy or sell a tract of land, you will certainly want to know its exact area, and you should be certain that no mistakes are made. either in the surveying of the land or in the calculation of its area.

If you do not own any land, the safest investment you can make is to buy some, but no one wants to pay out his money for several acres of land that he does not get, and neither does anyone want to sell more land than he gets paid for. All real estate agents should be very careful that they neither overestimate nor underestimate the true area of any farm they sell. For the protection of their clients, real estate agents should know how to calculate land areas, and how to check the surveyor's field work.

Only a few hours study of this little book are required to enable you to know how to survey and to check the accuracy of the field work, whether you or anyone else does the surveying. It also tells you how to calculate the area of any parcel of land, no matter what its shape is or how many corners it has. Nothing is required for the calculation except a pencil and a sheet of

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paper. No plotting or mapping is neccesary. Below is a brief description of the book:

Compass Surveying is clearly explained in the first part of this book to lay the foundation for the Calculation of Farm Areas. The first part is divided into 6 chapters, which are as follows:

Chapter I—A Lesson Explaining the Compass. Chapter II—How to Read the Compass. This chapter explains the Four Quadrants, Quarter Circles, Degrees, etc. Chapter III—How to Chain. Chapter IV—Instructions to Follow While Surveying. Chapter V—Variation of the Magnetic Needle. This chapter gives the yearly variation of the needle for almost every State in the U. S. and also tells you whether the variation is increasing or decreasing and the important part that the needle's variation plays in retracing lines of old surveys and how it is done. This chapter also tells you where you can get all the information on this subject free of charge. Chapter VI— Some Points of Law Governing Surveys. A knowledge of this chapter alone will probably be worth many times the price of the book to a large number of land owners. It may save many farmers from useless and expensive law suits over boundary lines. "Adverse Possession" is clearly explained as well as the length of time required for erroneous boundary lines to be established before the Law allows them to remain where they have been. This important chapter concludes Compass Surveying.

The Simplified Calculation Of Farm Areas

To make this study extremely clear and simple, a map of one of the best bluegrass farms in Virginia, calculated to contain 840.14 acres, is taken as an illustration. It is divided into two divisions, and a check calculation is made of each division. Two Calculation Sheets are attached and folded in the back of the book. Sheet No. 1 contains the calculation of the Western Division, and Sheet No. 2 contains the calculation of the Eastern Division. These two sheets are unfolded out to the right when they are being studied. The map of the 32-sided farm is also fixed and folded in the back of the book. While in use, it is unfolded up above the Calculation Sheets so

What Others Have to Say About

COMPASS SURVEYING

And The

SIMPLIFIED CALCULATION OF FARM AREAS

(Engineering News, Hill Building, New York.)

The accompanying notice appeared in our Engineering Literature Section for November 18, 1915, —Editor, Engineering News.

CAN FARMERS LEARN SURVEYING?

COMPASS SURVEYING AND THE SIMPLIFIED CALCULATION OF FARM AREAS—By Charles Mitchell Thomas, Civil Engineer and Surveyor, Wytheville, Va.: The Author, Cloth 6 x 8 in.; pp. vi 92; charts $2.

The author has set himself an almost impossible task. As he describes it: "If you own a farm or if you are thinking of buying one, it will be a great source of satisfaction to you if you know how to calculate its area, so that you will not have to take anothers word for it." He attempts to teach the real estate agent and the farmer the familiar double-meridian-distance method of computing an area from a metes and bounds description. This is a large order. He makes it more formidable by teaching also the principals and practice of compass surveying, with auxiliary remarks on magnetic declinations and on the adverse possession.

The most striking feature of the text are the language and style employed. They represent the author's effort to fit his words and argument to the intelligence of his reader. Unusual similes and methods of explaining difficult conceptions abound, and so also does a rich Virginian vocabulary not lacking in charm.

Engineering News confesses itself unable to judge whether the book will succeed in instructing the farmer; and, what is more, it does not believe in making every man his own surveyor or engineer. But the book recommends itself unreservedly to every college teacher of surveying as a helpful and suggestive contribution to the art of teaching the subject to unprepared minds. Beyond this, there is sound sense in a remark contained in an advertising circular that reached us with the book: "If you happen not to be interested, give your boy or girl a chance; perhaps they can catch on to the calculation even quicker than you."

A statement on page 26 may prove somewhat misleading. The author says: "When there is no fence on the line to be surveyed, and one corner can't be seen from another, a deed giving metes-and-bounds of the tract is required." This statement may be considered in several different ways; but in any event the reader should be acquainted more fully with the fact that a deed of the kind described may be useful even when one corner can be seen from another.

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ROBERT SAYERS
Attorney-at-Law
WYTHEVILLE. VA.

December 15, 1915.

Mr. C. M. Thomas,
Wytheville, Va.

Dear Sir:

I have examined, with interest, the copy of your Book on Surveying which I have purchased from you and I am of the opinion that it will be a great assistance to any person who undertakes to calculate the area of lands or run lines. I am also of the opinion that it is a book that will be useful to attorneys who have questions of title to look up, or land litigation. I find your explanations clear and easily comprehended by any person.

I think your book is well worth the purchase price.

Yours truly,

RS.--EB. ROBERT SAYERS

From
HON. E. LEE TRINKLE, State Senator
and Attorney at Law
WYTHEVILLE, VIRGINIA.

Dec., 18, 1915.

Mr. Charles M. Thomas,
Wytheville, Va.

My Dear Mr. Thomas:

I want to congratulate you upon the matter to be found in your book "Compass Surveying and the Simplified Calculation of Farm Areas," a copy of which I have recently purchased.

This book will be of great help to any one who desires to make any character of calculation relative to the area of land. It is certainly helpful to me as an attorney, and I should imagine that you would have no difficulty in finding ready purchasers for this book as I certainly regard the money spent in its purchase as most splendidly used.

I wish to congratulate you, as a Wytheville boy on your apparent knowledge of this character of work and on your energy in getting out this publication.

Yours respectfully,

DIC. ELT--GR. E. LEE TRINKLE

Now Governor of Virginia.

Lake Tahoe, California.
Dec., 25, 1915

Mr. Charles M. Thomas,
Wytheville, Va.

Dear Sir:

Your book at hand, and after looking over same, think I have made a good investment. I am a natural numb-scull at figures, have always wondered what a sine and a cosine were, (this being only an infinitesimal part of the grand ignorance) have bought many books on mathematics, which was claimed by the author to teach anyone arithmetic, this is partly why I think I am bad at learning. Wish you would let me know if there is any other books that you have along that line, or if you know of any books. I am sir,

Gratefully yours,

LYMAN MACDONALD

SPECIAL OFFER

In order to rush the sale of the remaining copies of the first edition of "COMPASS SURVEYING AND THE SIMPLIFIED CALCULATION OF FARM AREAS," to help to finance the publication of the second edition which will be still more valuable than the first edition, the Author will include, free of charge, with every book ordered, one of his "SIMPLIFIED TIME CHARTS,.' which is simple, unique and entirely new; nothing like it on the market.

THE TIME—CHART shows in a simple graphic form the relationship between Longitude and Time, giving the time all over the world at any hour of the day and at any place. It shows the four different divisions of Standard Time throughout the United States and also explains the perplexing question of how a boat gains or loses a day when it sails across the 180th meridian of Longitude, something that is very hard for most folks to understand.

The Author developed and published this Time-Chart while he was in the U. S. Navy, pursuing the study of Navigation.

At the bottom of the "SIMPLIFIED TIME-CHART" is printed an explanation of same, which when read over carefully, will easily enable the student to understand the Chart.

This Chart has been very highly recommended, and a knowledge of same should be possessed by every student throughout our Public and High Schools especially those studying Geography and Mathematics.

Price $0.50

NOTE: The Author will greatly appreciate it if you will pass the enclosed leaflets on to some one else whom you think will be interested in the publications described.

GUARANTEE

If, after reading over my book, "COMPASS SURVEYING AND THE SIMPLIFIED CALCULATION OF FARM AREAS," and carefully studying the Time-Chart you think that you have not gotten your moneys worth to the extent of $2.00. return same within one week and your money will be refunded.

Reference: The Farmers Bank, or any prominent or responsible party in Wytheville, Va.

CHAS. M. THOMAS, County Engineer,
Wytheville, Va.

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DOLPHUS KISER
Merchandise
BUCU, VIRGINIA.

Dec., 27, 1915.

Mr. Charles M. Thomas,
Wytheville, Va.

My Dear Mr. Thomas:

I was certainly pleased to hear from you again and wish to say I am very proud of the book I bought of you "Compass Surveying and the Simplified Calculation of Farm Areas." I had always thought that a very rough approximate of the acreage of a farm was all that could be expected of a surveyor unless he had a thorough knowledge of higher mathematics, but you have made it so simple in your book, that a man with a very ordinary education can learn to do very accurate surveying by the aid of your book, the value of your book lies in the simplicity of its teaching, and to those that have bought other books on the subject I wish to say don't class this book with them for I bought a book "Principals and Practice of Surveying" and it appeared so mysterious I am sure I never would have learned anything from it, but "Compass Surveying" with aid of the Traverse Chart and by carrying you through all parts of a complete survey and explaining each step in so simple a manner makes it of untold value to property owners with a limited education. So wishing you much success and a happy and prosperous New Year, I remain,

Very truly yours,
DOLPHUS KISER

C. C. DAVIS
Merchandise
LONG SPUR, VA.

Dec., 31, 1915

Mr. Charles M. Thomas,
Wytheville, Va.

Dear Sir:

Your letter of the 23rd inst., to hand and can say that your book on "Simplified Calculation of Farm Areas" I think is a noble piece of work, which makes the entire work plain and easy. Anyone with a very little education by a little time carefully studying as we do in other things that comes in our line about our farms, will enable us to make calculations for ourselves that will prove very valuable to all land owners. There is no high mathematics in the calculations of farm areas. I think the book a valuable piece of property myself.

Yours truly,
C. C. DAVIS

WALLER S. POAGE
Attorney at Law
WYTHEVILLE, VA.

Jan., 8, 1916

Mr. Charles M. Thomas,
Wytheville, Va.

Dear Sir:

I have examined with care your "Compass Sur-

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veying and the Simplified Calculation of Farm Areas," which I purchased of you, and I have no hesitation in saying it will, in my opinion be most useful to our profession.

Often questions relating to farm areas and surveying arise with us and I am sure your most excellent book will be useful to every lawyer in aiding him to solve them to his satisfaction, and it gives me great pleasure to recommend it.

Yours very truly,

DIC. WSP.--EP. **WALLER S. POAGE**

Now Solicitor of Currency, Washington, D. C.

From

HON. SAMUEL W. WILLIAMS

Late Attorney General of Virginia

Wytheville, Virginia.
Jan., 11, 1916.

Mr. Charles M. Thomas,
Wytheville, Va.

Dear Sir:

In my long practice as a lawyer, I have had considerable experience in Land Litigation, and I have to some extent dealt in real estate, and I often felt the need of a good book on surveying which was accurate, reliable and practical. I have examined your book on Compass Surveying and Simplified Calculations of Farm Areas, and I take pleasure in saying that I think this book meets a long felt want and will prove a very great benefit to all persons who are interested in correct land surveying.

I am an Advocate of Practical training for our children in the Public Free Schools in this State, and there is no practical subject of more importance than that covered by your book, and in my humble judgment this book ought to be adopted as a Text Book in the Public Free Schools in this state, and if so it will prove a great benefit towards advancing practical education in the Public Free Schools.

Yours very truly,

SWW--LS. SAMUEL W. WILLIAMS

Vancouver Barracks, Wash.
Oct., 28, 1917.

Mr. Chas. M. Thomas,
Wytheville, Va.

Dear Sir:

Having had the good fortune of seeing one of your books in the hands of one of our officers, and finding it a very simple and quick calculation I take great pleasure in ordering the same from you, to be delivered at your earliest convenience.

Inclosed two dollars to pay for same as advertised in your book, and oblige.

Lieut. FRED BOLDUC,
4th, Engineers.

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that the reader can glance from one to the other with ease. When the map and Calculation Sheets are being studied, the book should be placed on the top of a table and they should then be spread out flat on the table-top. Each Calculation Sheet is made up of 19 different columns, the columns being numbered from 1 to 19.

The Simplified Calculation of Farm Areas is made up of 7 chapters, as follows: Chapter I—A Few Suggestions and Instructions to the Reader. Chapter II—Explanations of the First Three Columns. These three columns are the surveyor's notes taken while surveying around the farm. Chapter III—Explanation of Columns Nos. 4, 5, 6 and 7, the Latitude and Departure Columns. This chapter explains the most important and the most interesting part of the calculation. It "shows up" the surveyor, so to speak, and tells whether he made an accurate or inaccurate survey of the farm. The Simplified Traverse Chart in the front of the book, and which is fully explained within the book, is used from which to pick off the numbers that go in these 4 different columns. This traverse chart is accurate enough for compass work, and takes the place of a 90-page traverse table, but the table in the back of the book can also be used for these columns if greater accuracy is desired. This table is clearly explained within the book. Chapter IV—Explanations of Columns Nos. 8, 9, 10, 11, 12 and 13. Columns 10, 11, 12 and 13 are the same as columns 4, 5, 6 and 7, but with a very small difference either added or subtracted. These small differences make up columns 8 and 9.

Chapter V—Explanations of Columns Nos. 14 and 15. These columns contain numbers obtained only by addition and subtraction, and are calculated quicker than any of the other columns from Column No. 3 up to 19. Column No. 14 is made up of the numbers from Columns 12 and 13. Column 15 is made up of the number from Columns 10 and 11. Columns 14 and 15 are very simple and easily derived after studying this chapter.

Chapter VI. — Explanations of Columns Nos. 16, 17, 18 and 19. Columns 16 and 17 contain products derived by multiplying the numbers in Column 14 by the corresponding numbers in Columns 10 or 11. Columns 18

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and 19 contain the products obtained by multiplying the numbers in Column 15 by the corresponding numbers in Columns 12 and 13. One area is calculated by taking one-half of the difference between the sums of Columns 16 and 17. A check area is calculated by taking one-half of the difference between the sums of Columns 18 and 19. These two areas should be *exactly* the same; if they are not, a mistake has been made by the calculator. By using this check method of calculation, a surveyor should be able to guarantee his calculations.

Chapter VII, Sheet No. 2—A Calculation of the Eastern Division. This chapter is simply a review of the 6 preceding chapters by containing the calculation of the area of the Eastern Division. It also contains the Metes and Bounds (bearings and distances) of 3 different farms of which the reader should calculate the area. The area of each farm is given, so the reader will know when he has calculated the correct area. This practice will be very helpful indeed to the reader.

The size of this book is 6 inches by 8 inches, and it contains all the information necessary to make anyone, who can multiply, a good surveyor and land calculator. If you happen not to be interested, give your boy or girl a chance; perhaps they can catch on to the calculation even quicker than you. However, at least one person on every farm should know how to calculate land. This is one very important point that is not taught in any of the public schools and in very few colleges. Most people think that land calculating is very difficult, but they are entirely mistaken; it just takes a little time, that's all. Any person, who has an average amount of common sense, which is possessed by most all land-owners, and is able to multiply, can learn how to calculate land quite readily after he has studied this book just a few hours.

The writer has written this little book especially for the use of farmers, and he hopes that they will find it very valuable, especially in keeping down contention among adjacent land-owners concerning boundary lines, lost corners, etc.

LIEUT. CHARLES M. THOMAS,
U. S. Coast and Geodetic Survey,
Washington, D. C.

The angle at knot No.2, added to the angle at knot No. 3 is always equal to 90 degrees, and of course the plumb-line makes an angle of 90 degrees with the edge of the table. Therefore, the sum of *all* the angles of a triangle is always equal to 180 degrees, no matter what shape the triangle has. The triangle made by the string and the edge of the table is called a RIGHT ANGLE TRIANGLE, because it always contains a *right angle* (90 degrees). Keep the string stretched fairly tight, and move knot No. 2 all the way from the edge of the table until it is exactly above knot No. 3; you will then easily see how the sine and cosine varies with the size of the angle. Continue this experiment until you are very familiar with the theory of the sine and cosine. Also keep the table of cosines and sines in front of you.

While you are performing this experiment, arrange the SIMPLIFIED TRAVERSE CHART, which you will find in the front of this book, so that it will lie on the table in front of you, with the Latitude line parrallel to the edges of the table; or, it might be understood even quicker if you tack it upon the wall in front of you, with the Latitude parallel to the top of the table and nearest the floor. You will then see that the degree lines represent the string, and that the corner where all of the lines on the chart come together, represents the corner of the table where you are holding knot No. 3. The Latitude line on the chart is represented by the edge of the table, and the plumb-line, from knot No. 2 down to the edge of the table, represents the Departure line on the chart.

The curve lines on the chart represent the curve made by knot No. 2, as you change the angles at knot No. 3. Of course, knot No. 2 makes only one curve, whose radius is only one foot; but you can see that the chart contains 28 curves. It represents a number of lines of different lengths. The numbers on this chart represent Chain lengths; however, they can be used for any unit of measure, such as 100 feet lengths.

On the chart the curved lines represent the length of different courses, and the *degree lines* (the 90 lines that are numbered along the top of the chart and down along the right hand side) represent the 90 different *bearings* that can be sighted by the compass from any corner, with a difference of 1 degree between them. The *horizontal* lines represent the distance in Latitude of any course. The *vertical* lines represent the distance in Departure of the course. In experiment, just above, the distance the plumb-line is from the corner of the table at knot No. 3, measured along the edge of the table, is represented on the chart by the *horizontal* or Latitude lines. The distance knot No. 2 is above the edge of the table is represented on the chart by the *vertical* or Departure lines. Curve No. 12 on the chart makes the same curve as knot No. 2 in the experiment, because each has a *radius* of 1 foot. (RADIUS is 1/2 the *Diameter* of any circle.) However, each curve on the chart represents a certain distance from the corner. The scale of the chart, when used for *traversing* the boundary lines of a farm, is 1 inch equals 1 *chain.*

It should now be easily understood why the length of any course multiplied by the *cosine* of the bearing gives the *Latitude,* and also why the length of any course multiplied by the *sine* of the bearing gives the *Departure* of the course. *This chart can* *be used for all four quadrants.* It consists only of *Degree lines, Distance curves, Latitude,* and *Departure* lines. The distance curves are 1 chain apart, by scale; they are numbered up along the Latitude line, and at the bottom, along the Departure line. The Latitude lines are represented by the same numbers that the distance curves are, and so are the Departure lines. It is seen that no degree lines are drawn to a fraction of a degree, such as ½ or ¼ degree. You will also notice that no distance curves are drawn to the fraction of a chain. These extra fraction lines and distance curves are left off, as they might cause confusion, and would probably cause the calculator to make more errors than he would without them. You can very easily judge one-fourth or one-half the distance between any two degree lines, and a rule, divided into 10ths of an inch, should be used to find the correct distance between any two distance curves, and on the proper *degree line.* This is done by measuring out, from the nearest distance curve, the correct number of 10ths, and measuring them on the proper degree line.

Suppose a course is given as follows: S 39 degrees E, 17.70 chains. At the top of the chart find the 39 degree line, and place your rule along it. Find the point where it crosses the 17-chain distance curve; from this point measure, with your rule, 7/10th of an inch back towards the figure 39. You then have your proper distance on the proper degree line. Now trace, from this point, the horizontal line out to the left hand side of the chart, to the Latitude line. You will find this horizontal line to cut the Latitude line at the point 13.75. This is the *South Latitude* of the course. Go back to the same point on the

39 degree line, and trace the vertical line down to the bottom of the chart, on the Departure line. You will find that it cuts the Departure line at the point 11.15 inches from the lower left-hand corner. This shows that the *East Departure* is 11.15 chains. By the use of the chart, you can calculate (or traverse) to the nearest 1/10th of a chain, and somewhat closer. This is close enough for *compass* surveying. (To *traverse* a course is to find its *Latitude* and *Departure* from its bearing.) If greater accuracy is desired by the calculator, he will find a table of *Cosines* and *Sines,* in the back of this book, from ¼th of a degree up to 89¾ degrees, with a difference of only ¼th of a degree between the bearings. You can get the *Latitude* exactly by multiplying the length of the course by the *Cosine* of its bearing; and you can calculate its *Departure* exactly by multiplying the length of the course by the *Sine* of its bearing.

Suppose you want to calculate the Latitude and Departure of the Division Line of the Carter Farm. Its bearing and distance is S 12½ degrees E, 113.25 chains. To obtain the Latitude and Departure of this course, the chart would have to be about 6 times as large as it is; but this course can be traversed in two ways: first by Cosines and Sines, which is done as follows: Cosine of 12½ degrees is equal to .976; 113.25 × .976 equal to 110.53200 chains, the South Latitude of this course. The Sine of 12½ degrees equals .216; 113.25 × .216 equals 24.46200 chains, the East Departure of the course.

By the chart, the course is traversed as follows: 113.25 divided by 6 equals 18.87 chains. As you see, this distance is within the limits of the chart. On the chart place your rule exactly between the 12 and 13 degree lines. Find the point where the distance is 18.87 from the corner, and trace off the Latitude and Departure corresponding to this point. Latitude of the distance 18.87 chains is 18.42 chains, and you will find the Departure to be 4.08 chains. Multiply each of these by 6, the same number that you divided the entire length by. Then 18.42 × 6 equals 110.52 chains, the Latitude of the entire course. The Departure of the entire course is 4.08 × 6 equal to 24.48 chains. If you wanted to traverse the courses on sheet 1, a calculation of the Western Division, you should divide course 1-2 by 2; the length of the course 3-4 should be divided by 2; 5-6 should be divided by 2; and course 7-8 should be divided by 6, as was shown above. But always be certain to multiply the Latitude and Departure by the *same* number that you used to divide the length of the line by.

On the chart, the light horizontal and vertical lines represent 10ths of a chain, or the distance of 10, 20, 30 links, the distance between these light lines is 1/10th of an inch, equal by scale to 10 links.

The most accurate way to calculate the Latitude and Departure of several courses is to multiply the length of the line by the cosine of the bearing to get the Latitude; and multiply the length of the same course by the sine of the same bearing to get the Departure. Use the chart as a quick method of checking your latitudes and departures. You will make fewer mistakes and can be more certain of yourself if you follow the above suggestion.

Now for the explanation of Column No. 4 (Latitude, North or plus Latitude).

You will notice that there are only *three* latitudes in this column, which are 3.34, 110.54, and 1.23. You will notice that each of these North Latitudes is opposite either a *N.* E. or *N.* W. course in the bearing column, No. 2.

You should have your rule handy, so that you can measure and check all distances that I explain to you, so that you can be certain that you understand them perfectly. Remember that the map is drawn to a scale of 10 chains equals 1 inch. When the distances check, you will then be certain that you understand everything as you go along from column to column.

COLUMN NO. FIVE—LATITUDE SOUTH OR MINUS LATITUDE.

For convenience, in the calculation of areas, *North* is considered as plus (+); and *South* is considered as minus (—), as it is *opposite* to North; *East* is plus (+), and *West* is considered minus (—). Just remember this simple little rule: N. E. *plus, plus;* and S. W. *minus, minus.*

In column 5 you will notice that each *South* latitude is opposite either a *S.* E. or a *S.* W. bearing in column 2. For every *S.* in the bearings in column 2 there is a corresponding *South* latitude in this column, No. 5. In the first line, 1-2, the South latitude 39.91 is the distance that corner No. 2 is *South* of corner No. 1, measured on a *South* line, through corner No. 1, to the point on this South line that is exactly *West* of corner No. 2. You will notice that the sum of these twelve South latitudes is 112.94 chains. The sum of the three North latitudes in column 4 is 115.11 chains. In a *perfect* survey these sums should be exactly the same, because if you start at any corner on your farm and walk all the way around it and come back to the corner from which you started, the distance you walked towards the South should be equal to the distance you walked towards the North, and this is the reason why the sum of column 4 should equal the sum of column 5. In this survey they differ as will be shown: 115.11 — (minus) 112.94 = (equals) 2.17 chains, or about 143.2 feet. *Right here is where we have the first sure way of checking the accuracy of the surveyor and the chainmen.* We see that the plus, or North Latitude, column No. 4, is greater by 2.17 chains than the minus or South, column No. 5. This difference is too great, and the farm should have been surveyed over again, so as to find out where the error is; but as no survey was made, we will go ahead and use these notes, for *no* farm area can be computed *exactly,* as you will see later.

When we examine column No. 4, we see that the Division Line ,7-8, makes up most all of the North Latitude. It is very probable that this line was surveyed over some rough ground, such as steep hills and hollows, and the chainmen did *not* hold the chain level, and, of course this made the measurement too large, which, in return, made the North Latitude too great. If you were asked to check over the first survey and find the error, you would very probably find the error in the length of this line, 7-8.

COLUMN NO. SIX—THE EAST OR PLUS DEPARTURE.

You will notice that each of these East Departures is opposite an *E* in the bearing column No. 2; that is, a course that is either N. *E*. or S. *E*. Line 6-7 is *due* East, and of course its *Departure* is equal to its entire length, 14.25 chains. The sum of the five East departures is 74.40.

COLUMN NO. SEVEN—THE WEST OR MINUS DEPARTURE.

There are eleven West Departures, and each one is opposite a *W* in the bearing column; that is, either a N. *W*. or a S. *W*. course. The sum of these eleven West departures is 74.51 chains, only .11 of a chain or 11 links greater than the sum of column No. 6. This small difference of 11/100th of a chain in Departure is well within the allowable limit, but the error of 2.17 chains in Latitude should not have been allowed; nevertheless, we have it, and will have to make the best of it. The calculation of a survey with an error like this will teach the student more about this method than the calculation of a survey that closed almost exactly. You will find this fact out later.

A very good allowable limit is to divide the PERIMETER (sum of column No. 3) of the farm by the *Sum* of the *Error in Latitude* and the *Error in Departure,* and if the answer is *less* than 100 for *cheap* land or less than 200 for *high-priced* land, it would be best to resurvey the farm, and be much more accurate with this survey. So you see, that if the distance around a farm of very good land is, say 250.00 chains, the sum of the error in latitude and the error in departure must not be over 1.25 chains, because 250.00 divided by 1.25 equals 200. It is always best for the surveyor to use his judgment in determining the allowable error, as this should always depend on the price of the land that has been surveyed. Right here is where the surveyor has the advantage over the land owner, because no matter how inaccurate a survey might have been, the surveyor can go ahead and *make the survey close* in his calculation, and figure out an area for the land owner that might be even 10, 20, or even 50 or more acres less, or perhaps greater than the area really is, and may cause a person to either buy or sell many acres of land that he does not possess. Every land owner should know at least enough about the Calculation of Farm Areas to be able to look over the surveyor's calculation and check the accuracy of the survey that he made. However, a good surveyor would never make such a mistake in his survey without resurveying and correcting the mistake before he continued to calculate the area.

The motto of this little book is *"Better Surveying and Fewer Law Suits"*, and I hope that this volume may help some along this line. The more knowledge that land owners have about the few simple principals of surveying, the less the amount of money will be that they may waste in court. We will now go back to our subject, as we have just finished our *mental recess.*

In columns No. 3, 4, 5, 6, 7, up to 19, the numbers to the *left* of the decimal point are the number of *Chains,* and the numbers to the *right* of the point are the numbers of *Links* in addition. Just like $47.25 means 47 dollars and 25 cents more, so does the distance from 1-2, 47.25 mean 47 chains and 25 links more.

CHAPTER IV.

EXPLANATION OF COLUMNS NOS. 8, 9, 10, 11, 12, 13.

COLUMN NO. EIGHT—A AND B.

We have just finished with the Latitude pair of columns, and the Departure pair of columns, and compared the sums in each pair separately. Now the next object in the calculation is to *make* the North and South in the Latitude columns 4 and 5 balance or equal each other, and also to *make* the East and West in the Departure columns No. 6 and 7 balance or equal each other. You can readily see that we will have to *subtract* about 1.08 chains from 115.11 (the sum of column No. 4), and that we will have to *add* 1.09 chains to column No. 5. It is not necessary that the *sum* of column 8-A should be equal to 1.08 chains *exactly*; but the sum of column 8-B, added to the sum of column 8-A should *exactly* equal the *Error in Latitude* (the difference between the sums of column 4 and 5). However, it is always best to have the sum of column 8-A equal, as near as possible, to the sum of column 8-B. In like manner, the sum of column No. 9-A should be equal, as near as possible, to the sum of column 9-B. As you will notice at the top of column 8-A, North (N) has a *minus* sign. Now don't confuse this with a former statement that North is considered as *plus*. This minus sign simply means that all the numbers were *subtracted* from the corresponding numbers in column No. 4. The 1.08 chains has to be distributed among all of the three North Latitudes. As you will notice, the 1.08 is about 1/100th of the sum of column 4 (115.11); so in this case, a good rule to follow in distributing the 1.08, is to divide each number in column 4 by 100 (or multiply by .01, which is the same thing), and put the number of links you get in column No. 8-A. As I have said before, this error in latitude is too great to balance up, but the method of *balancing* is better shown here where the error is large.

Column No. 8-B contains the number of links that have to be *added* to the corresponding South Latitudes in column No. 5. As you can see, the number of *links* in column No. 8-B is just about the same as the number of *chains* in column No. 5. This is because one-half the error in latitude is nearly 1/100th of the sum of the South Latitudes in column No. 5. The sum of column 8-A and 8-B should *always* be *exactly* equal to the Error in Latitude. As is noticed at the top of column 8-B, the South or (S) has a plus sign. This is because all the numbers in this column are *added* to the corresponding South Latitudes in column No. 5.

COLUMN NO. NINE—A AND B.

Column No. 9-A contains the numbers that have to be *added* to the corresponding East Departures in column 6. This is the only reason that the "E" at the top of the column has a plus sign. You will see that one-half the Error in Departure is .055 chains, or 5½ links. 6 links is distributed throughout column 9-A, and 5 links are distributed throughout column 9-B.

.05 of a chain divided by 74.40 chains (sum of column 6) equals .0007, approximately. If each of the numbers in the

East departure column No. 6 be multiplied by .0007 you will get the proper number of *links* for column No. 9-A, corresponding to each number. Take the first East departure for an example:

25.29 × .0007 = .017703 of a chain, approximately .02 of a chain or 2 links, because .017 is nearer .02 than it is to .01. However, by using your judgment in distributing the error, you needn't bother about multiplying the Latitudes and Departures for the corrections in columns 8 and 9, but the longer the line, the greater the correction. Some lines will be so short that they will need no corresponding correction at all.

For review of columns 8 and 9 remember that column 8-A contains the corrections for the North Latitude column No. 4. Column No. 8-B contains the corrections for the South Latitude column No. 5. Column No. 9-A contains the corrections for the East Departure column No. 6. Column No. 9-B contains the corrections for the West Departure column No. 7.

The sum of columns 8-A and 8-B must exactly equal the Error in Latitude, and the sum of columns 9-A and 9-B must equal exactly the Error in Departure.

COLUM NO. TEN—BALANCED NORTH LATITUDE.

This column is exactly the same as column No. 4, after the N. corrections in column 8-A have been *subtracted* from the corresponding North Latitudes in column 4. The sum of column 10 is 114.05 chains, 1.06 chains *less* than 115.11 chains, the sum of column 4.

COLUMN NO. ELEVEN—BALANCED SOUTH LATITUDE.

This column is column No. 5, after the corrections in column 8-B have been *added* to the corresponding South Latitudes in column 5. The sum of this column, No. 11, is 114.05 chains, the same as the sum of column No. 10. This shows that the North and South Latitude columns now *balance*. The sum of column 10 must *always* be *exactly equal* to the sum of column 11, and you must be certain that this is the case before you continue the calculation. If the sums are *not* equal, then you must find out where your mistake is and correct it.

COLUMN NO. TWELVE—BALANCED EAST DEPARTURE.

This column is the same as column 6, *plus* the corresponding corrections in column 9-A. The sum of this column, No. 12, is 74.46 chains, .06 of a chain *greater* than column No. 6.

COLUMN NO. THIRTEEN—BALANCED WEST DEPARTURE.

This column is the same as column No. 7, *minus* the corresponding corrections in column 9-B. The sum of column 13 is 74.46 chains, equals the sum of column 12. Therefore, the East and West departures are *balanced*. You must *always* be certain that the sum of these two Departure columns are *exactly equal* before you continue the calculation.

Now, as far as the calculation of the area is concerned, we have finished with all the columns from No. 1-A up to 9B, inclusive; or, in other words, we could cut the sheet in two between columns 9-B and 10, and the first 9 columns could be destroyed, as they have no further value in the calculation; but of course there is no use doing this, as the entire calculation sheet should be saved, for you might need it for future reference.

CHAPTER V.

EXPLANATION OF COLUMNS NO. 14 AND 15.

COLUMN NO. FOURTEEN—THE DOUBLE MERIDIAN DISTANCES (D. M. D.).

Now here is the column that scares most inexperienced surveyors and calculators; but, really, it is the simplest and prettiest column of them all, with the exception of column 15, which is very much on the same order as column 14, and will be explained later. Many people who can neither read nor write can subtract and add with rapidity in their heads. Well, the calculation of this column is nothing but *addition* and *subtraction,* and that is all there is to it, as you will now see. You will never have to add more than three numbers at a time, and most any small child in the third or fourth grade of a public school can do this. The notes on sheet 1 are started from the most *Western* corner, corner No. 1. This is the corner from which the D. M. D. should be calculated; so of course all the D. M. Ds. will be to the *East* and their sign will be *plus,* because the entire farm is East of the most Western corner. This is why the D. M. D. column has a *plus* sign, and each D. M. D. is plus throughout the entire column. The farm is on the East side of the MAIN MERIDIAN (a North and South line through the most Western corner).

I will now explain to you what the Double Meridian Distance of any course really is. Take your rule and pick out the *middle point* of any line on the map of the Western Division. Measure the distance from this middle point, along a *West line* to the *main meridian* (the North and South line through the most Western corner, No. 1). *Double* this distance by multiplying it by 2, and you then have the *Double Meridian Distance* of this course. Remember that 1 inch = 10 chains = 40 poles on the map.

You know now what the D. M. D. of a course is. I will next tell you *how to get it.* You can now fold up your map for awhile. On sheet 1 cover up all of the columns except columns 12, 13 and 14, with a newspaper or some other kind of scrap paper. This will avoid confusion, and you will know where the D. M. D. comes from; it comes from the uncovered columns 12 and 13, the two *Departure* columns. *Always* remember the following three rules while you are calculating the D. M. D.:

RULE I.—The D. M. D. of the *First* Course is *equal* to the *Departure* of the First Course *itself.*

RULE II.—The D. M. D. of the *Second* Course is *equal* to the D. M. D. of the *First* Course plus, or minus, the *Departure* of the *First* Course, plus, or minus, the *Departure* of the *Second* Course *itself.*

RULE III.—The D. M. D. of *any* Course is *equal* to the D. M. D. of the *preceding* Course, plus, or minus, the *Departure* of this *preceding* Course, plus, or minus, the *Departure* of the Course *itself.*

I will now explain *when* to *add* and *when* to *subtract*. When the D. M. D. has a *plus* sign through the column, as is the case in column 14, the *East* Departures in column 12 are *added,* and the *West* Departures in column 13 are *subtracted.* However, if the calculation is begun from the most *Eastern* corner, all the D. M. Ds. will then be measured to the *West* and all of them will have a *minus* sign. In a case of this kind, you should *subtract* all of the *East* Departures, and *add* all of the *West* Departures, because all numbers with *opposite* signs are *subtracted,* and those which have the same signs, such as plus, and plus, or minus and minus, are *added.*

For example we will illustrate Rule III by calculating the D. M. D. of the course 7-8, the Division Line. The D. M. D. of the preceding line (6-7) has been calculated to be, plus 120.94 chains, and the *departure* of this preceding course is (plus) +14.26 chains, and the departure of the course itself is (minus) —24.46 chains. So here is the simple little calculation in addition and subtraction that bluffs most inexperienced calculators of land areas. It is done as follows: +120.94 + 14.26 = +135.20 chains. 135.20 — 24.46 = 110.74 chains, the D. M. D. of the Division Line 7-8. Now what was hard about that simple little problem? And that one is just about as hard a D. M. D. to calculate as you will ever run across, so you needn't worry about the future.

From Rule I we obtained the D. M. D. of the first course (1-2), by simply copying its *East* Departure, plus 25.31 chains.

From Rule II we calculate the D. M. D. for the second course (2-3), by simply *adding* +25.31 (the D. M. D. of the *first* course) and +25.31 (its *departure*), and +.15 (the *departure* of the *second* course), as follows: +25.31 + 25.31 + .15 = +50.77 chains, equals the D. M. D. of the second course (2-3).

The remaining D. M. Ds. are calculated by Rule III, as was done in the example before. Rule III is followed in calculating all the rest of the D. M. Ds. The small numbers in this column are the East and West departures, taken from columns 12 and 13; they are in this column merely for the purpose of showing more clearly how the D. M. Ds. are calculated.

The beauty about the calculation of the D. M. D. column is the excellent *check* you have on your work. When you calculate the D. M. D. for the *last* course, you should find it *exactly equal to* the *Departure* of this last course, but *having an opposite sign.* If this is not the case, you should go over all of your D. M. D. calculations again until you find your mistake. After correcting the mistake, you must continue the calculation until you do get the last D. M. D. to check with the corresponding Departure of the last course, but with an opposite sign.

The D. M. D. column should be calculated on a separate piece of paper, so that if it does not check the first time, you do not have to rub out all the D. M. Ds. on your calculation sheet, which would cause a very untidy looking column. When you calculate the D. M. Ds. on a separate sheet of paper, make *check marks* by your D. M. Ds., so that you will not make a mistake and copy down a *departure* instead of the proper D. M. D. However, they should not be copied down in column 14 until the last D. M. D. checked out all right with the *opposite departure* of the last course. The D. M. Ds. should be copied opposite (on the same horizontal line with) their corresponding courses.

Don't get discouraged if you have trouble in getting the D. M. D. column to check. Be certain that your Departure columns, 11 and 12, are exactly balanced, and that your addition and subtraction is correct for every D. M. D. If all of these are correct, the D. M. D. column *has* to check out all right Usually the mistake is made by *adding* a Departure when it should have been *subtracted,* or *subtracting* a Departure when it should have been *added.* If you already have a map made of the farm you are calculating, you could check your work by measuring, with a rule, the D. M. D. of each course. By this method you will soon find the course that will not check, and your mistake will very probably be in it.

Before calculating the area of a farm, it is a very good idea to make a rough *plot* or *map* of the farm, using a rule and a PROTRACTOR (a half-circle divided into degrees). You plot your bearings with the protractor, and scale off the proper distances with the rule or scale. After this is done, you will then know which is the most Western, most Eastern, most Northern, and most Southern corners. It is sometimes hard to pick out the most Western and Southern corners just by inspecting columns 1, 2 and 3, the Metes and Bounds of the farm; and unless the surveyor, or calculator, is familiar with the farm that he is calculating, it will be by far the safest plan for him to make a plot of the farm, so that he will know for certain which is the most Western, and which is the most Southern corner. When plotting he will always have to have a *Meridian* on his plotting paper—that is, a North and South line. Also an East and West line, which of course will be *perpendicular* to the Meridian. Plotting paper should be used if it can be obtained. This is paper that is ruled off into vertical (North and South) lines, and horizontal (East and West) lines. By the knowledge that the student should have gained from Book I, he should not have any trouble at all in plotting a map of a farm.

Column No. Fifteen—Double Equatorial Distance, (D. E. D.).

This is very much like the D. M. D. in column 14, and would actually be the D. M. D. if the farm could be revolved about its most Southern corner, No. 5, through the North East quadrant. This can easily be understood by sticking a pin through the map at corner No. 5, and turning the map, on a table, through the N. E. quadrant. The East and West line, before the map was swung around, is now the North and South line.

Here is what the D. E. D. is: With your rule, pick out the middle point of any course on the map, say course 1-2, and measure its distance *down* along a *South* line *to* the East and West line through corner 5, the most Southern corner. *Double* this distance by multiplying it by 2, and you will then have the Double Equatorial Distance of that course. (*"Equatorial"* is derived from the word *"Equator"*.)

Now, the only reason for working out the D. E. D. is to give us another way to calculate the area of the farm. If both areas are the same, then we are certain that the calculated area is correct, according to the surveyor's notes. However, the *exact* area cannot be calculated unless the survey was *perfect,* which would be shown by the sum of column No. *4* being equal to the sum of column No. *5*, and the sum of column No. 6 being equal to the sum of column No. 7. This rarely, if ever, happens in compass surveying. However, the chain's length must be exactly correct before this exact area can be calculated.

As you will notice in column No. 15, the D. E. D is not started at the top of the column, but is started from the most Southern corner, No. 5. It is always best to start calculating the D. E. D. from the most *Southern* corner, just for the same reason that it is best to start calculating the D. M. D. from the most *Western* corner.

I will now tell you how to calculate the D. E. D.. Take some paper and cover up all of the columns except No. 10, 11 and 15.

RULE I. The D. E. D. of the *First* Course is equal to the *Latitude* of the *First* Course *itself*.

Example: We started calculating the D. E. D. from corner No. 5. Therefore 5-6 is considered the first course. Its Latitude is +3.30 chains. You will see that this is also the D. E. D. of this course, 5-6.

RULE II. The D. E. D. of the *Second* Course is *equal* to the D. E. D. of the *First* Course, plus, or minus, the *Latitude* of the First Course, plus, or minus, the *Latitude* of the Second Course *itself*.

Example: Course 6-7 is considered the second course in this calculation. The D. E. D. of the first course 5-6 is +3.30, and the Latitude of the first course is also +3.30; but you see that 6-7 has no Latitude because it is a due *East* course. Therefore $+3.30 + 3.30 + 0.00 = +6.60$ chains, the D. E. D. of the course 6-7.

RULE III. The D. E. D. of *any* Course is equal to the D. E. D. of the *preceding* Course, plus, or minus, the *Latitude* of *this preceding* Course, plus or minus the *Latitude* of the Course *itself*.

Example: The third course is, in this calculation, 7-8. The preceding course is 6-7, and its D. E. D. is +6.60 chains, but whose latitude is *zero* (0). The latitude of the third course, 7-8, is +109.54 chains. Therefore +6.60 + 0.00 + 109.54 = +116.14 chains, equals the D. E. D. of this course, 7-8. Follow Rule III throughout the entire calculation for the remaining D. E. Ds., and if the last one is equal to the corresponding *Latitude* with its *sign changed,* then your calculation of this D. E. D. column is correct. You should also calculate the D. E. D. column on a separate sheet of paper, like you did the D. M. D., and make a check mark by each D. E. D., so that you will not make the mistake of copying down a Latitude instead of a D. E. D. when you are transferring them onto the calculation sheet. However, before you do this, be certain that the last D. E. D. you calculated is exactly equal to its corresponding latitude with its sign changed. After you get the last D. E. D. to check out, then copy them down in their proper column, and corresponding to their proper courses—that is, on the same horizontal line with them.

The D. E. D. of any course *must* be on the same horizontal line with it, as must be the case with all the Latitudes, Departures, D. M. Ds., etc., for any course.

Always remember that when the D. E. D. column is *plus* (as in this case), the North Latitudes in column 10 have to be *added,* and the South Latitudes in column 11 have to be *subtracted.* This is the case when the calculation of the D. E. D. started from the most *Southern* corner, *and this is the proper corner from which to start calculating the D. E. D.* However, if the calculation is started from the most *Northern* corner, then all D. E. D.s. will be measured towards the South and all of them will have a *minus* sign before them, and the *North* Latitudes, which have a *plus* sign (column No. 10), have to be *subtracted,* and the *South* Latitudes, which have a *minus* sign, have to be *added.* The calculator is more likely to make mistakes if he begins his calculation from the most Northern corner, so avoid doing this.

The prominent, or large, numbers in column No. 15 are the D. E. Ds. of the corresponding courses, and are the only numbers required in the column. The small numbers are the North and South Latitudes copied from columns 10 and 11, with their proper signs. They are placed in this column simply to show how the D. E. D. is calculated.

CHAPTER VI.

EXPLANATION OF COLUMNS NO. 16, 17, 18, 19.

COLUMN NO. SIXTEEN—THE NORTH DOUBLE AREAS.

This column contains only the *products* of the D. M. Ds. in column 14, and their corresponding *North* Latitudes, in column 10. When a D. M. D. is multiplied by a *North* Latitude, the *product* is placed in this *North* Double Area column, No. 16, on the same horizontal line.

COLUMN NO. SEVENTEEN—THE SOUTH DOUBLE AREAS.

This column contains only the *products* of the D. M. Ds. in column 14, by the corresponding *South* Latitudes, in column No. 11, and placed on the same horizontal line in this column No. 17.

As you will notice, the column No. *16* is 12427.3837 *square chains,* and the sum of this column, No. 17, is 4355.3682 *square chains.*

We have gone far enough now to be able to calculate *one* area of the farm. When we *subtract* the sum of column 17 from the sum of column 16, the difference is 8072.0155 *square chains;* and this is equal to *double* the area of the farm. As you know, 10 Square Chains equal 1 *acre,* we will divide the difference by 2, and then by 10. The result, as you see on sheet 1, is just about *403.6 acres.* This is the calculated area of the farm. We will now finish our other calculation and see if it checks this area that we have just calculated.

COLUMN NO. EIGHTEEN—THE EAST DOUBLE AREAS.

You will now see where the D. *E.* D. comes into use. This column, No. 18, contains only the *products* of the D. E. Ds., in column 15, by their corresponding *East Departures* in column No. 12. The sum of this column is 3998.7680 *square chains.*

COLUMN NO. NINETEEN—THE WEST DOUBLE AREAS.

This column contains only the *products* of the D. E. Ds., in column 15, by their corresponding *West Departures.* The sum of this column is 12070.7835 *square chains.*

Now for a short review on the last four columns, the Double

Area Columns. As you will notice, for every *North* Latitude, in column 10, you have a *North* Double Area, on the same horizontal line in column 16. For every *South* Latitude, in column 11, you have a corresponding *South* Double Area in column 17. For every *East* Departure, in column 12, you have a corresponding *East* Double Area in column 18. And for every *West* Departure, in column 13, you have a corresponding *West* Double Area in column 19. We will now find our check from columns 18 and 19. The difference between the sums of these two columns is 12070.7835 — 3998.7680 = 8072.0155 *square chains.* This is also *double* the area of the farm in *square chains.* We divide this number by 2; this gives us the area of the farm in square chains, but there are *10* square chains in one Acre, so we divide the number of square chains by 10, just like we did for columns 16 and 17. Our result is 403.6 *acres,* the exact area that was calculated from columns 16 and 17. This method of working out two separate areas gives us a check on all the multiplications required for the last four columns, and also a check on the addition of the last four columns. This check shows that the entire calculation is correct.

By using the D. E. D., one calculator can check his own work; whereas, if only the D. M. D. is used and *one* area calculated, it is not a good idea to accept this *one* calculation unless another person has made a separate calculation which agreed close enough with the first calculation. Two calculators can use exactly the same metes and bounds (bearings and distances) of a farm, and yet they will rarely, if ever, calculate *exactly* the same area. All of the columns of each calculator will very probably, and really *should,* be the same from column No. 1 all the way up through column No. 7. The difference in their calculations begins in columns 8 and 9, as *no* two calculators are very likely to distribute the errors in latitude and departure in exactly the same manner. As for example, take the first correction in column 8-B, .39 of a chain. Now, another calculator might have a .38 or a .40 of a chain, and so on for any of the numbers in columns 8 and 9. You can readily see that this will change the remaining 10 columns, but will change them only a *very* small amount. So this is the reason that two calculators differ, to a small amount, in their calculations of the same farm when each calculator uses the same notes as the other.

However, when the D. E. D. is used, only one calculation is necessary, as two separate calculations of the area are made by the same calculator, and when they check, his work is generally bound to be correct. It is almost an improbability that the calculator could make a mistake in each calculation and yet have the final areas to check out. However, this is *possible* but not at all *probable.* If two calculators make a calculation of the area of the same farm, and each one checked his work by using the D. E. D., it is very likely that these areas would not be exactly the same either, and yet each one checked his work by the D. E. D. method and found it to be correct. This is on account of the difference being in columns 8 and 9, as was explained above. If all of the columns of one's calculation from column 1 through column 9-B are exactly the same as the columns of the other calculation, then the remaining 10 columns should be the same, and both calculators should get exactly the same area.

From column 15 on through the remaining 4 columns, the *theory* of this method of calculation generally becomes quite hazy in the minds of the most experienced surveyors and calculators, but as *results* are all that are generally desired by most people, I will not try to explain this theory any further than by merely saying that the columns 16 and 17 contain *double* areas of triangles and trapezoids, both inside and outside of the farm. Columns 18 and 19 also contain double areas of triangles and trapezoids, both inside and outside of the farm. (A TRAPEZOID is a four-sided plane figure of which two sides are parallel and the other two are not.)

By now you should be familiar enough with this simple method of calculating to be able to calculate the area of a farm by yourself. Is there anything hard about this calculation? All there is to it is addition, subtraction, multiplication, and only *short* division. Any ten-year-old boy or girl should be able to do all of the figuring that is necessary in this calculation. Of course *practice* in this kind of land calculation is what makes anyone familiar with it, but after you once learn how, even if you do forget a few of the simple principals, just a few hours study of this book, including the calculation sheets, map and chart, will be all that is necessary to make you once more familiar with this simple calculation. The only thing I ask of you is for you to keep your *eyes open* while you are studying this little book, and use all of your *good common sense,* and most land owners generally have plenty of it to use

CHAPTER VII.

SHEET NO. 2—A CALCULATION OF THE EASTERN DIVISION.

This calculation of the Eastern Division is begun at the most Western corner, corner No. 8.

One corner must not have more than *one* number; so instead of calling this corner No. 1, we still call it No. 8, and the second corner is No. 7.

We will now review this method of calculation by using Sheet No. 2, and I will tell you again how to go about the calculation, step by step.

First copy down columns No. 1, No. 2, and No. 3 out of the surveyor's note-book, containing the *metes* and *bounds* of the farm, being certain that *all courses* are included and in their proper order.

Then start at the top of the sheet, opposite the first course, and *multiply* the *length* of the *course* by the *cosine* of the *bearing,* and place the product in the proper *Latitude* column, No. 4 or No. 5. The proper column is shown by *the first letter* in the *bearing,* column No. 2, which is either N. or S. *Multiply* the *length* of the *same course* by the *sine* of the *bearing,* and place the product in the proper *Departure* column, No. 6 or No. 7. The proper column is shown by the *last* letter in the *bearing,* which is either E. or W.

After you have traversed the courses down through the last course at the bottom of the sheet, you should then *check* all of the Latitudes with the Traverse Chart, and also check all of the Departures the same way, as has been explained before. Be *certain* that you haven't a *South* Latitude in the North Latitude column, and that you haven't a *North* Latitude in the South Latitude column. Likewise, be certain that *all* of the East Departures are in the East column, No. 6, and that *all* of the West Departures are in the West column, No. 7.

You should then add up each column separately. If the sum of column 4 is about the same as column 5, and if the sum of column 6 is nearly the same as the sum of column 7, the survey was accurate enough if you do not get a number *less* than 100 or 200 (depending on the value of the land) when you divide the perimeter of the farm (sum of column 3) by the sum of the errors in Latitude and Departure. If either the Latitude columns, 4 and 5, or the Departure columns, 6 and 7, do not agree close enough, you should see if you didn't put one or more of your Latitudes or Departures in the wrong column. Correct all mistakes, and after you are satisfied that the N. and S. latitudes agree close enough, and that the E. and W. Departure columns agree within the required limits, you should then balance each pair, as was explained before, making each Latitude column take ½ the error in Latitude, and each Departure column take ½ the error in Departure.

After the Latitude columns, 10 and 11, are *exactly* balanced, and after the Departure columns, 12 and 13, are *exactly* balanced, as is shown by the sum of column 10 being exactly equal to the sum of column 11, and the sum of column 12 being exactly equal to the sum of column 13.

The D. M. D. column is calculated from corner No. 8, the most Western corner, of the Eastern Division, 8-7 being the *first* course. This column is calculated from the Departure columns, Nos. 12 and 13, as has been explained before.

Column No. 15, the D. E. D. column, was calculated from corner 13, the most Northern corner. This corner was chosen, instead of the most Southern corner, just for the sake of a change, to show you how the *Minus* D. E. D. is calculated. The only difference is that the plus or *North* Latitudes are *subtracted,* because they have the *opposite* sign, and the minus or *South* Latitudes are *added,* because they have the same sign as the D. E. Ds.

Column 16 contains the products of the D. M. Ds., and their corresponding North Latitudes in column 10. Column 17 contains the products of the D. M. Ds. and their corresponding minus or South Latitudes. Column 18 contains the products of the numbers in the D. E. D. column and their corresponding East Departures, column No. 12. Column 19 contains the products of the D. E. Ds. and their corresponding West Departures in column No. 13. All of the multiplication must be done on separate sheets of paper. As you will see, there were 18 multiplications required to fill out columns 16 and 17, and there were 19 problems in multiplication required to fill out columns 18 and 19. For example we will take the first product in column 18 and show how it was obtained. 132.34 (D. E. D.) × 24.70 (E. Departure) = 3268.7980 square chains; but, as you will notice, the last two figures on the right-hand end of all the products, in the last four columns, are left off. So we make this number 3268.80 square chains. This is done only for brevity.

An area is calculated from the difference between columns 16 and 17. This area is 436.54 acres. Another area is calculated from the columns 18 and 19. We find this area to be 436.54 acres also. We then know that this area of 436 54/100 acres is correct, according to the surveyor's notes, which are rarely, if ever, perfect.

It would now be a good practice for the student to calculate the area of the entire farm, leaving out the Division Line, 7-8. You have all of the Latitudes and Departures worked out for you on Sheet 1, and Sheet 2. For practice you should check them on your Traverse Chart and also by the table of Cosines and Sines. Compute your D. M. D. from the most Western corner, No. 1, and calculate your D. E. D. from the most Southern corner, No. 5. Work out two areas for the entire farm and see that they check. Compare this area with the sum of the areas in the Western and Eastern Division. These results will not agree exactly, on account of the errors in Latitude and Departure, which have to be balanced in all three calculations.

Another *approximate* method of calculating the area of a farm is by what is called TRIANGULATION. This method consists in making a plot or map of the farm with a protractor and scale, or rule, and then divide the area of the farm up into triangles by joining convenient corners. The next step is to find the area of each triangle, and add them all together for the entire area.

The area of any triangle is equal ½ the product of the *base* of the triangle by the *altitude* of the triangle. The *Altitude* of the triangle is the *shortest* distance from any one of the three *angles* to the *opposite* side, which is the *Base.* Any triangle has *three* altitudes and *three* bases. You will get the correct area of the triangle no matter which base and corresponding altitude you take.

When the lengths of the bases and altitudes are scaled off, always remember what scale the map is drawn to—that is, how many chains equal 1 inch. This method of triangulation was the only method of calculating areas used by many of the old surveyors in the past; but it should never be used except in calculating the area of very cheap land, where the calculation does not have to be accurate.

When you desire to calculate the area of a farm, get a large sheet of paper and rule it full of horizontal lines about ¼th of an inch apart. Then draw your vertical lines so that the sheet will be divided up into the proper number of columns, 19; however, it isn't neccessary to have the entire 19 columns down on the sheet. Column No. 1 can be omitted, and also columns 8 and 9, as you can add and subtract the corrections in your head. Columns 10 and 11 can be thrown into one column, with a plus sign before the North latitudes and a minus sign before the South latitudes. Columns 12 and 13 can also be thrown into one column, placing a *plus* sign before all *East* departures and a *minus* sign before all *West* departures.

Calculation sheets, already ruled and printed, can be furnished by the Southwestern Virginia Land Agency's Surveying Department, of Wytheville, Virginia, at a cost of only five cents each, to cover cost of printing and postage. These sheets are 23 inches by 9 inches, having 24 horizontal lines, one sheet holding all the calculation necessary for finding the area of a 24-sided farm. If the farm has more than 24 sides, carry forward the calculation from one sheet to the next.

For the benefit of the student I give below the metes and bounds of three separate tracts. Two areas of each should be calculated for practice.

Beginning at the most Western corner: N 86½° E 18.05 chains; N 11½° E 8.40 chains; N 82½° E 9.58 chains; S 8° E 24.00 chains; S 16° W 5.50 chains; S 81° W 24.75 chains; N 15° W 24.12 chains to the beginning. Make a plot and also a second calculation, using the D. E. D. from the most *Southern* corner. You will find the area to be about 72 acres. Let either 10 chains equal 1 inch on your plot, or if you have a large sheet of plotting paper, let 5 chains equal 1 inch. You will find the Latitude error to be about .96 of a chain, and the error in Departure to be about .33 of a chain, or 33 links.

Here is another tract of land, having ten sides: Beginning at the most Western corner, and leaving same N 81° E 24.75 chains; S 77° E 4.02 chains; S 18¼° E 8.90 chains; S 16¼° W 2.75 chains; S 13¾° E 2.20 chains; S 81° W 4.50 chains; S 75¾° W 10.00 chains; S 57¾° W 7.50 chains; S 34° W 6.70 chains; N 15° W 24.12 chains to the beginning corner. If you traverse these courses correctly you will find the error in Latitude to be about .32 of a chain, and the error in Departure to be .41 of a chain. The area is about 47.4 acres. Make a plot of this farm, pick out the most Southern corner and calculate the D. E. D. and check your D. M. D. area.

Here is a third farm with thirteen sides: Beginning at the most Western corner and running S 19° E 9.15 chains; N 83½° E 27.75 chains; N 7¾° W 9.75 chains; N 4¼° E 3.90 chains; N 28¾° E 4.75 chains; S 74½° W 6.20 chains; N 12° W 7.05 chains; S 81° W 4.50 chains; S 75¾° W 10.00 chains; S 57¾° W 7.50 chains; S 34° W 6.70 chains; S 11° W 2.00 chains; S 16° W 2.25 chains to the beginning. Make a plot of this farm and find the most Southern corner, from which calculate the D. E. Ds. and check the area you computed by using the D. M. D. You will find the North Latitude .62 of a chain greater than the South Latitude. The West Departure is .85 of a chain greater than the East Departure. You will find the area to be just about 59 acres.

After you have become efficient enough to be able to calculate the area of the three tracts above by Latitude and Departure, you will never regret the few hours and study that you spent in learning the few simple facts and principals contained in this little book.

Table of Cosines and Sines.

Bearing	Lat. Cosine	Dep. Sine
0°	1.000	.000
¼°	1.000	.004
½°	1.000	.009
¾°	1.000	.013
1°	1.000	.017
1¼°	1.000	.022
1½°	1.000	.026
1¾°	1.000	.031
2°	.999	.035
2¼°	.999	.039
2½°	.999	.044
2¾°	.999	.048
3°	.999	.052
3¼°	.998	.057
3½°	.998	.061
3¾°	.998	.065
4°	.998	.070
4¼°	.997	.074
4½°	.997	.078
4¾°	.997	.083
5°	.996	.087
5¼°	.996	.091
5½°	.995	.096
5¾°	.995	.100
6°	.995	.105
6¼°	.994	.109
6½°	.994	.113
6¾°	.993	.118
7°	.993	.122
7¼°	.992	.126
7½°	.991	.131
7¾°	.991	.135
8°	.990	.139
8¼°	.990	.143
8½°	.989	.148
8¾°	.988	.152
9°	.988	.156
9¼°	.987	.161
9½°	.986	.165
9¾°	.986	.169
10°	.985	.174
10¼°	.984	.178
10½°	.983	.182
10¾°	.982	.187
11°	.982	.191
11¼°	.981	.195
11½°	.980	.199
11¾°	.979	.204
12°	.978	.208
12¼°	.977	.212
12½°	.976	.216
12¾°	.975	.221
13°	.974	.225
13¼°	.973	.229
13½°	.972	.233
13¾°	.971	.238

Bearing	Lat. Cosine	Dep. Sine	Bearing	Lat. Cosine	Dep. Sine
14°	.970	.242	21°	.934	.358
14¼°	.969	.246	21¼°	.932	.362
14½°	.968	.250	21½°	.930	.366
14¾°	.967	.255	21¾°	.929	.371
15°	.966	.259	22°	.927	.375
15¼°	.965	.263	22¼°	.926	.379
15½°	.964	.267	22½°	.924	.383
15¾°	.962	.271	22¾°	.922	.387
16°	.961	.276	23°	.920	.391
16¼°	.960	.280	23¼°	.919	.395
16½°	.959	.284	23½°	.917	.399
16¾°	.958	.288	23¾°	.915	.403
17°	.956	.292	24°	.914	.407
17¼°	.955	.297	24¼°	.912	.411
17½°	.954	.301	24½°	.910	.415
17¾°	.952	.305	24¾°	.908	.419
18°	.951	.309	25°	.906	.423
18¼°	.950	.313	25¼°	.904	.427
18½°	.948	.317	25½°	.903	.431
18¾°	.947	.321	25¾°	.901	.434
19°	.946	.326	26°	.899	.438
19¼°	.944	.330	26¼°	.897	.442
19½°	.943	.334	26½°	.895	.446
19¾°	.941	.338	26¾°	.893	.450
20°	.940	.342	27°	.891	.454
20¼°	.938	.346	27¼°	.889	.458
20½°	.937	.350	27½°	.887	.462
20¾°	.935	.354	27¾°	.885	.466

BEARING	LAT. COSINE	DEP. SINE	BEARING	LAT. COSINE	DEP. SINE
28°	.883	.469	35°	.819	.574
28¼°	.881	.473	35¼°	.817	.577
28½°	.879	.477	35½°	.814	.581
28¾°	.877	.481	35¾°	.812	.584
29°	.875	.485	36°	.809	.588
29¼°	.872	.489	26¼°	.806	.591
29½°	.870	.492	36½°	.804	.595
29¾°	.868	.496	36¾°	.801	.598
30°	.866	.500	37°	.799	.602
30¼°	.864	.504	37¼°	.796	.605
30½°	.862	.508	37½°	.793	.609
30¾°	.859	.511	37¾°	.791	.612
31°	.857	.515	38°	.788	.616
31¼°	.855	.519	38¼°	.785	.619
31½°	.853	.523	38½°	.783	.623
31¾°	.850	.526	38¾°	.780	.626
32°	.848	.530	39°	.777	.629
32¼°	.846	.534	39¼°	.774	.633
32½°	.843	.537	39½°	.772	.636
32¾°	.841	.541	39¾°	.769	.639
33°	.839	.545	40°	.766	.643
33¼°	.836	.548	40¼°	.763	.646
33½°	.834	.552	40½°	.760	.649
33¾°	.831	.556	40¾°	.758	.653
34°	.829	.559	41°	.755	.656
34¼°	.827	.563	41¼°	.752	.659
34½°	.824	.566	41½°	.749	.663
34¾°	.822	.570	41¾°	.746	.666

BEARING	LAT. COSINE	DEP. SINE
42°	.743	.669
42¼°	.740	.672
42½°	.737	.676
42¾°	.734	.679
43°	.731	.682
43¼°	.728	.685
43½°	.725	.688
43¾°	.722	.692
44°	.719	.695
44¼°	.716	.698
44½°	.713	.701
44¾°	.710	.704
45°	.707	.707
45¼°	.704	.710
45½°	.701	.713
45¾°	.698	.716
46°	.695	.719
46¼°	.692	.722
46½°	.688	.725
46¾°	.685	.728
47°	.682	.731
47¼°	.679	.734
47½°	.676	.737
47¾°	.672	.740
48°	.669	.743
48¼°	.666	.746
48½°	.663	.749
48¾°	.659	.752
49°	.656	.755
49¼°	.653	.758
49½°	.649	.760
49¾°	.646	.763
50°	.643	.766
50¼°	.639	.769
50½°	.636	.772
50¾°	.633	.774
51°	.629	.777
51¼°	.626	.780
51½°	.623	.783
51¾°	.619	.785
52°	.616	.788
52¼°	.612	.791
52½°	.609	.793
52¾°	.605	.796
53°	.602	.799
53¼°	.598	.801
53½°	.595	.804
53¾°	.591	.806
54°	.588	.809
54¼°	.584	.812
54½°	.581	.814
54¾°	.577	.817
55°	.574	.819
55¼°	.570	.822
55½°	.566	.824
55¾°	.563	.827

Bearing	Lat. Cosine	Dep. Sine	Bearing	Lat. Cosine	Dep. Sine
56°	.559	.829	63°	.454	.891
56¼°	.556	.831	63¼°	.450	.893
56½°	.552	.834	63½°	.446	.895
56¾°	.548	.836	63¾°	.442	.897
57°	.545	.839	64°	.438	.899
57¼°	.541	.841	64¼°	.434	.901
57½°	.537	.843	64½°	.431	.903
57¾°	.534	.846	64¾°	.427	.904
58°	.530	.848	65°	.423	.906
58¼°	.526	.850	65¼°	.419	.908
58½°	.523	.853	65½°	.415	.910
58¾°	.519	.855	65¾°	.411	.912
59°	.515	.857	66°	.407	.914
59¼°	.511	.859	66¼°	.403	.915
59½°	.508	.862	66½°	.399	.917
59¾°	.504	.864	66¾°	.395	.919
60°	.500	.866	67°	.391	.920
60¼°	.496	.868	67¼°	.387	.922
60½°	.492	.870	67½°	.383	.924
60¾°	.489	.872	67¾°	.379	.926
61°	.485	.875	68°	.375	.927
61¼°	.481	.877	68¼°	.371	.929
61½°	.477	.879	68½°	.366	.930
61¾°	.473	.881	68¾°	.362	.932
62°	.469	.883	69°	.358	.934
62¼°	.466	.885	69¼°	.354	.935
62½°	.462	.887	69½°	.350	.937
62¾°	.458	.889	69¾°	.346	.938

Bearing	Lat. Cosine	Dep. Sine
70°	.342	.940
70¼°	.338	.941
70½°	.334	.943
70¾°	.330	.944
71°	.326	.946
71¼°	.321	.947
71½°	.317	.948
71¾°	.313	.950
72°	.309	.951
72¼°	.305	.952
72½°	.301	.954
72¾°	.297	.955
73°	.292	.956
73¼°	.288	.958
73½°	.284	.959
73¾°	.280	.960
74°	.276	.961
74¼°	.271	.962
74½°	.267	.964
74¾°	.263	.965
75°	.259	.966
75¼°	.255	.967
75½°	.250	.968
75¾°	.246	.969
76°	.242	.970
76¼°	.238	.971
76½°	.233	.972
76¾°	.229	.973
77°	.225	.974
77¼°	.221	.975
77½°	.216	.976
77¾°	.212	.977
78°	.208	.978
78¼°	.204	.979
78½°	.199	.980
78¾°	.195	.981
79°	.191	.982
79¼°	.187	.982
79½°	.182	.983
79¾°	.178	.984
80°	.174	.985
80¼°	.169	.986
80½°	.165	.986
80¾°	.161	.987
81°	.156	.988
81¼°	.152	.988
81½°	.148	.989
81¾°	.143	.990
82°	.139	.990
82¼°	.135	.991
82½°	.131	.991
82¾°	.126	.992
83°	.122	.993
83¼°	.118	.993
83½°	.113	.994
83¾°	.109	.994

Bearing	Lat. Cosine	Dep. Sine
84°	.105	.995
84¼°	.100	.995
84½°	.096	.995
84¾°	.091	.996
85°	.087	.996
85¼°	.083	.997
85½°	.078	.997
85¾°	.074	.997
86°	.070	.998
86¼°	.065	.998
86½°	.061	.998
86¾°	.057	.998
87°	.052	.999
87¼°	.048	.999
87½°	.044	.999
87¾°	.039	.999
88°	.035	.999
88¼°	.031	1.000
88½°	.026	1.000
88¾°	.022	1.000
89°	.017	1.000
89¼°	.013	1.000
89½°	.009	1.000
89¾°	.004	1.000
90°	.000	1.000

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